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Group Treatment of Multicompany Plating Wastes The Taunton Silver Project

Reed and Barton Silversmiths, Taunton, MA

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Industrial Environmental Research Lab -Cincinnati, OH

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Group Treatment of Multicompany Plating Wastes

The Taunton Silver Project

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-CI) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report is a product of the above efforts. This study was undertaken to establish feasibility of a joint waste treatment plant owned and operated by three companies that generate compatible wastes. The study presents problems and costs of a joint treatment versus individual treatments.

Participants of this study decided against coownership of a joint treatment plant. However, other groupings of companies may decide on the joint treatment route.

Information contained in this report will be of particular value to EPA's Regional Offices and to operators of small plants in urban areas for whom it is difficult to install an individual treatment system. Within EPA's R&D program the information will be used as part of the continuing program to seek and evaluate nonconventional approaches to minimize industrial waste discharges.

For further information concerning this subject the Industrial Pollution Control Division should be contacted.

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ABSTRACT

The requirements for industrial pretreatment will limit the entrance of metals into municipal treatment facilities in many communities. Within a city or region, opportunities for grouping waste streams from several similar companies for combined treatment may exist. This project was designed to consider three companies from the metal-related field in the City of Taunton, Massachusetts, as possible candidates. The intent was to explore the treatment technology applicable to this segment of the electroplating industry in order to determine the potential for cost savings with group treatment and also to develop the legal and institutional arrangements necessary for successful implementation and operation.

Technical and economic data are presented on individual control alternatives for each of the three companies as well as on group treatment, with several variations for concentrated wastes and sludges. In addition, the potential for material recovery and water reuse within the various control alternatives is developed. Finally, the appropriate institutional and financial factors for ownership and operation of an industrial group treatment facility are described.

The project is an outgrowth of a Section 208 (PL 92-500) areawide wastewater management plan under development by the Southeastern Regional Planning and Economic Development District (SRPEDD) of Massachusetts as an alternative approach to meeting pretreatment requirements.

The materials in the report are designed to assist the companies in determining whether they should treat particular elements of their waste separately or jointly. They are also designed to assist EPA in deciding to encourage group treatment facilities as a matter for research and policy direction.

This report was submitted in fulfillment of Grant No. S-805181 by Reed & Barton Silversmiths under the partial sponsorship of the U.S. Environmental Protection Agency.

This report covers the period of January 1, 1977 to September 1, 1977, and the work was completed as of April 1, 1977.

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METRIC CONVERSION TABLE

1 foot = 30.48 centimeters

1 gallon = 3.78 liters

1 inch = 2.54 centimeters

1 mile = 1.61 kilometers

1 pound = 0.45 kilograms

1 square mile = 2.59 square kilometers

1 troy ounce = 31.1 grams

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Sincere thanks are given to George S. Thompson, Chief, Metals and Inorganic Chemicals Branch and Mary K. Stinson, Project Officer, also Metals and Inorganic Chemicals Branch, Industrial Environmental Research Laboratory, U. S. Environmental Protection Agency. Both have given their valuable administrative and technical assistance as well as their moral support and cooperation.

J. H. Shockcor, P. E., has served as principal investigator in this project, providing the technical and economic analyses of the individual and group treatment alternatives. Janet M. Levy of Environmental Engineers Inc. of Concord, New Hampshire, assisted in the development of costs relative to the various alternatives.

Development Sciences Inc. (DSI) of East Sandwich, Massachusetts, provided the discussion of institutional and financial factors associated with ownership and operation of the group treatment alternatives and prepared the final report. Marsha Gorden of DSI served in a coordinating capacity among the participating groups.

The cooperation of the City of Taunton's Sewer Department and their consulting engineers, CE Maguire Inc. of Providence, Rhode Island, in providing appropriate data is greatly appreciated. Special thanks are due the Taunton Area Chamber of Commerce for their assistance in the preliminary industrial survey.

The three companies provided technical and engineering assistance as required to meet the time schedule for the project's work elements. With the direction of Andrew A. Kurowski, General Manager of F. B. Rogers Company, Kenneth L. Bundy, Plant Engineer of Reed & Barton Silversmiths, and Richard Kaplan, Vice President of Poole Silver Company, the following plant personnel's services are acknowledged: Robert E. Waits of F. B. Rogers Company, Donald H. MacDonald, Jr., of Poole Silver Company, and Francis Souza and Joseph F. Coelho of Reed & Barton Silversmiths. The cooperation of all is appreciated.

CHAPTER I

INTRODUCTION

OBJECTIVE

This project has been designed to test the feasibility of bringing together and treating common wastewater streams from three manufacturers of silver and silverplated holloware. In particular, the study has been planned to explore alternative group industrial wastewater treatment technologies applicable to this segment of the electroplating industry for three basic purposes:

- To determine the potential for cost savings with joint treatment,
- To develop the legal and institutional arrangements necessary for joint treatment implementation, and
- To encourage opportunities for material recovery and industrial water reuse.

A project of this nature can demonstrate the opportunities for aggregating materials within a region to accomplish environmental goals at reduced costs.

The issue of economy of scale for this industry made up of many small companies has never been demonstrated in a group project of this nature. Accordingly, this study has been designed to develop the technical/institutional/financial factors necessary to evaluate joint and individual treatment alternatives. If the problems were viewed only from the treatment perspective, its utility as an example would be limited. However, by incorporating the legal, institutional and reuse components, a holistic view of the industry problem is presented. By including these components, the solution is of value to Taunton as well as to others looking for answers to similar problems.

It should be recognized, however, that any example is a unique combination in terms of size, product, associated waste streams, and nearby disposal opportunities. Consequently, this project should be viewed not as strictly typical of this industry or the region but rather as an example presenting a group of variables and circumstances which are useful as a model. In this way, the report can be read as a demonstration of an evaluative approach and thus can be more useful to a larger audience.

PROJECT HISTORY

This project was an outgrowth of a Section 208 (PL92-500) areawide wastewater management plan under development by the Southeastern Regional Planning and Economic Development District (SRPEDD) of Massachusetts. In the course of investigating the impact of industrial wastewater discharges, it became apparent that opportunities existed for joint treatment of similar industrial waste streams in the study area. Analysis of industrial effluents in the several river basins under SRPEDD's planning jurisdiction indicated similar waste streams in proximity to each other, particularly in the City of Taunton.

This city has a long history of metal crafting beginning with America's first ironworks in 1656. From that start the city has favored industry rather than agriculture, building a tradition of metalworking which, today, takes the form of silverware, bronze and copper ware, stainless steel, pewterware, and other metallic items. Many of the present-day companies employ electroplating processes that, as a group, release a variety of metals to the Taunton River, either through direct discharge or through the municipal treatment plant.

In mid-summer of 1976, a series of meetings with the major silver companies in the greater Taunton area on the subject of joint industrial wastewater treatment was held under the auspices of SRPEDD, as part of its Areawide Wastewater Management Plan program activity with task responsibility assigned to Development Sciences Inc. (DSI), East Sandwich, Massachusetts. As a result of these meetings, a committee was formed by three of the silver companies to deal with the concept of joint waste stream treatment and DSI was requested by the committee to seek assistance from the Environmental Protection Agency to demonstrate feasibility.

During the fall of 1976, a project team was assembled by the silver company committee under the chairmanship of Andrew Kurowski, General Manager of F. B. Rogers Silver Company. This team included the committee members from Reed & Barton; F. B. Rogers; Poole Silver Company; a consultant on wastewater treatment, J. H. Shockcor, P.E.; and DSI. Continuity of purpose was maintained and in early November of 1976, a formal grant application for funding assistance was submitted to EPA with Henry C. Gill, Vice President of Manufacturing at Reed & Barton, serving as Project Manager and J. H. Shockcor as Principal Investigator.

Upon approval of the grant application in May of 1977, the project team initiated the program elements in the work plan. This cooperative effort received the full support of each of the participating firms in completing the following scope of work:

Program Element	Objective(s)	Output
1. Plant Evaluations	Investigate plant processes to determine waste stream types, present treatment systems and which streams go to sewers and/or local receiving waters.	Schematic flow diagrams for each participating plant showing location of waste generators and discharge points.
2. Data Acquisition	Identify and catalogue each waste stream by quantity, location and chemical analysis.	Statistical data will be added to the schematics developed in Element I. Tabular and schematic displays will be used to facilitate evaluation.

Project Element	Objective(s)	Output
3. Data Evaluation	Data accumulated during Element II will be evaluated for adequacy and accuracy. Expansion of existing data base will be accomplished where needed.	The displays in Element II will be modified and expanded to show common characteristics and potential for joint treatment.
4. Develop Alternate Concepts	Alternative treatment, recovery and disposal systems will be developed. Emphasis will be on technical feasibility compatible with industrial processes to achieve compliance with future regulatory standards. In addition, where technically and economically promising, the consideration of nearby plants with similar processing units and waste streams will be investigated. In particular, attention will be paid to Sheffield Silver Company of Norton and Poole Silver Company in Fall River.	Narrative and schematic descriptions of each feasible alternative treatment, recovery disposal system.
5. Develop Cost Comparisons	Detail costs for alternative system components including in-plant process changes where needed will be obtained. An optimum treatment scheme will be emphasized as a concluding phase of this element.	A tabular display showing various system components by major alternative will be shown including estimated O&M costs.
6. Report	A report providing all data showing the development of a feasible joint or individual treatment program will be written for potential publication by EPA. Emphasis will be on universal application of methodology, but with specific applicability for implementation by the participating industries.	A report with narrative and schematic illustrative drawings.

TAUNTON AND MUNICIPAL SEWAGE TREATMENT

The City of Taunton, which translated from the Gaelic means "town by the river," is one of three urban centers located in the Taunton River Basin. Brockton and Fall River share the same watershed, at the northern and southern extremities respectively. Urban activity is concentrated in about 30 percent of the 530 square miles* included in the basin with apparel, leather products, textiles, electrical machinery and fabricated metal products as major industries.

In 1967, the Division of Water Pollution Control, Commonwealth of Massachusetts, classified the waters of the basin to recognize proposed uses. An SB classification (swimming and agricultural uses) was assigned to the Taunton River as a tidal estuary flowing through the municipal environs of the City of Taunton and a B classification to the Mill River, an immediate tributary. Figure 1-1, a "Classification Map of Taunton River Basin," shows the locations of the municipal Taunton Treatment Plant as well as the project silver companies.

The Taunton River Basin Plan, in order to achieve the assigned levels of water quality, developed objectives for effective water pollution control based upon seven major municipal wastewater treatment plants. All of the basin treatment plants except two, Somerset and Fall River at the southern extremity of the watershed, will be required to provide advanced wastewater treatment. On essentially this basis, then, the City of Taunton is presently completing an expanded "secondary" level treatment facility plus ammonia removal to replace an older "primary" plant, constructed in 1950, with marginal hydraulic capacity. This new plant will have a 1995 design year capacity of 8.4 million gallons per day (mgd) average daily flow to serve a population of 40,900 persons living within approximately a 50-square-mile urban and suburban area.

Wastewater received at the Taunton treatment facility contains waste material generated from the use of water for domestic, commercial and industrial purposes. The original industrial survey of 1971 estimated a total of 2.0 million gallons per day from the wet processing industries including textiles, rubber and plastics, leather and metal fabrication. At the present time the industrial pattern has changed with new companies coming into the area and older companies beginning to consider water conservation techniques. Accordingly, the design year capacity of 8.4 mgd is projected to contain approximately 1.0 mgd of industrial wastewater with higher than normal BOD and SS such as from textiles and food processing, and 0.5 mgd of industrial wastewater with lower than normal BOD and SS such as from the metalworking industries.

The National Pollutant Discharge Elimination System (NPDES) permit for the City of Taunton's treated effluent requires a 93 percent Biochemical Oxygen Demand (BOD) removal under average design flow, discharging to the Taunton River. An activated sludge type of treatment process utilizing pure oxygen followed by chlorination has been selected to meet the requirements of the NPDES permit. Sludge is to be thickened, heat treated, dewatered and landfilled. The treatment facility has been designed to provide advanced biological treatment to city wastes and will require maximum operation efficiency to comply with discharge permit standards.

*See Metric Conversion Table, page v.

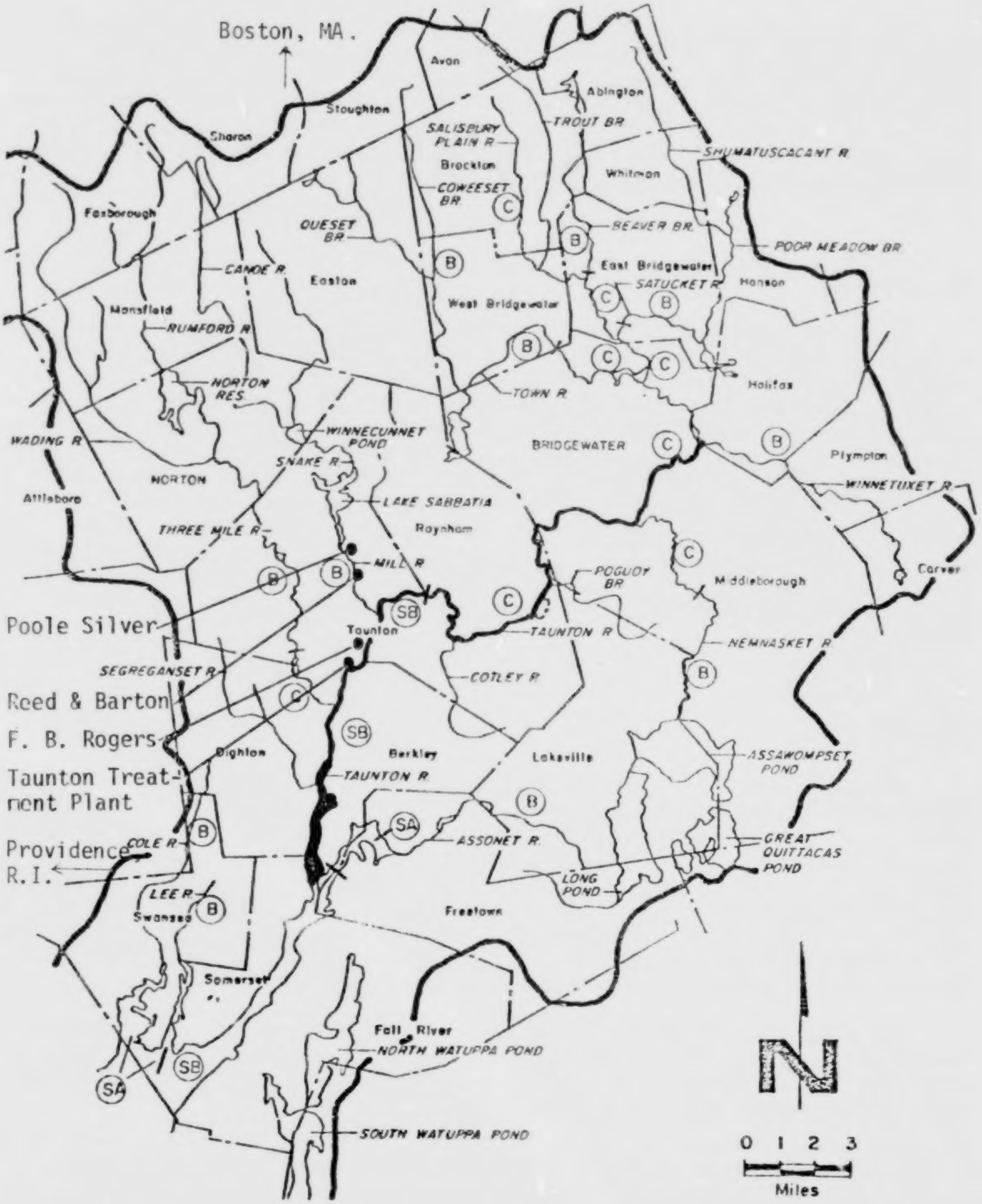
Boston, MA.
Avon
Abington
Stoughton
Sharon
SALISBURY PLAIN R
TROUT BR
SHUMATUSCACANT R
Brockton
Whitman
COWEESET BR
Foxborough
QUESET BR
BEAVER BR
POOR MEADOW BR
CANOE R
Easton
East Bridgewater
SATUCKET R
Hanson
Mansfield
West Bridgewater
RUMFORD R
NORTON RES
Halifax
TOWN R
WADING R
WINNECUNNET POND
BRIDGEWATER
Plympton
SNAKE R
WINNETUXET R
Attleboro
NORTON
LAKE SABBATIA
Raynham
THREE MILE R
MILL R
POGUOY BR
Middleborough
Carver
Poole Silver
Taunton
TAUNTON R
NEMASKET R
SEGREGANSET R
COTLEY R
Reed & Barton
F. B. Rogers
Dighton
Berkley
Lakeville
ASSAWOMPSET POND
Taunton Treatment Plant
TAUNTON R
Providence R.I.
COLE R
ASSONET R
GREAT QUITTACAS POND
LONG POND
LEE R
Swansea
Freetown
Somerset
Fall River
NORTH WATUPPA POND
SOUTH WATUPPA POND
N
0 1 2 3
Miles

FIGURE 1. CLASSIFICATION MAP OF TAUNTON RIVER BASIN. Source: The Taunton River Basin, Part A Water Quality Data, Department of Environmental Quality Engineering, Commonwealth of Massachusetts, Division of Water Pollution Control, Westborough, MA. December 1975.

This strict reduction of BOD, along with the selection of a biological treatment process, has necessitated the development of a sewer ordinance tightly regulating the entrance of toxic materials. As described in Appendix E, "City of Taunton Sewer Ordinance," the metals limits in particular have been set at low levels. Accordingly, companies in the city have begun to consider pretreatment steps and this project represents one set of alternatives for three companies manufacturing similar products.

THE COMPANIES

The three companies participating in this project represent an extension of Colonial America's early tradition of metal craft, which included silversmithing. Reed & Barton, founded in 1824, is one of the country's oldest and largest silverware manufacturers, presently producing a varied product line of tableware and holloware. Poole Silver Company, a Division of Towle Manufacturing Company of Newburyport, Massachusetts, has been in Taunton since 1893 and produces silverplated and pewter holloware. These two companies are located on the Mill River, a tributary of the Taunton, as shown in Figure 1, "Classification Map of Taunton River Basin." F. B. Rogers Silver Company, a wholly-owned subsidiary of National Silver Industries, Inc., is located directly on the Taunton River where it has a long history of producing silverplated and pewter holloware. Detailed descriptions of the plants appear in the first three appendices.

SUMMARY

During the period of this project, the City of Taunton, with its Conservation Commission, has begun a Riverbank Beautification Program. With the assistance of Comprehensive Employment Training Act (CETA) employees, initial steps to clear sites for walking and cross-country running have been taken. The preliminary plans call for additional land acquisition and future work to provide foot-bridges over the river, a bicycle path and a boat landing.* Since most of the Taunton River has already been identified and now is charted as a Wampanoag Indian Canoe Passage** across southeastern Massachusetts, there is additional interest in the river's past uses for transportation and fishing.

The completion of an industrial pretreatment program such as this report describes along with the upgrading of the municipal sewage treatment plant will encourage these additional activities along the river in accordance with the water quality goals previously established.

---

* Further information available from the Taunton Conservation Commission, P.O. Box 247, Taunton, MA 02780.

** "Wampanoag Commemorative Canoe Passage," prepared by Plymouth County Development Council in cooperation with the Bristol County Development Council.

CHAPTER II

CONCLUSIONS

TECHNICAL VIEWPOINT

1. Group treatment of process wastewater is feasible for batch discharges.
2. Group treatment of rinses is practical only when companies are close enough to render collection costs insignificant.
3. Selection of wastes suitable for group treatment must be specialized by type.

ECONOMIC VIEWPOINT

1. Significant cost reductions can be realized by greater utilization of batch treatment equipment through multicompany use than by individual company use.
2. Reduction in operating expenses for group treatment facilities can result from salvage of metal values. For this particular study silver is the predominant metal to be reclaimed. If there are increased amounts of raw waste, copper and nickel recovery will become attractive.
3. Group treatment at another location will prove most interesting to the company that is limited in space or personnel and/or is small in size. The prospects for other companies to join, therefore, are enhanced.
4. Group treatment at its site will prove most attractive to the company that has available space and personnel.

ENVIRONMENTAL VIEWPOINT

1. Group treatment will provide a higher quality of discharge by use of more appropriate technologies, higher qualified personnel and better methods of operation.
2. Optimization of individual plants to evaluate wastes for group treatment can suggest the most appropriate disposal site to match the particular characteristics of waste.
3. Group approaches encourage maximum water conservation techniques and material recovery options.

4. Group approaches can present a single solution/site for residual material disposal rather than a multiplicity.
5. Group approaches can decrease the number of monitoring points for regulatory agencies.

INSTITUTIONAL VIEWPOINT

1. Group arrangements for waste handling and disposal are feasible for companies willing to accept responsibility and work together.
2. Financing alternatives will require at least one company with ability to borrow necessary funds.
3. Role of pollution control bonding for group treatment may depend upon IRS acceptance of material recovery for tax exemption within project.

PROJECT OUTCOME

1. At the conclusion of the final report, the companies believed that group treatment was a technical and institutional arrangement of merit.
2. The three companies, however, were not able to join a group project. One company had completed planning for its batch waste treatment facilities as it was on an earlier compliance schedule. A second company elected to merge its metal finishing operations with another firm within the parent company. The third company, however, has provided its own batch treatment facility using design concepts that would permit it to expand capacity on a contract basis if desirable.

CHAPTER III

RECOMMENDATIONS

TO THE ENVIRONMENTAL PROTECTION AGENCY:

1. Encourage use of group solutions where conditions are similar to those of this study. The methodology of this report can be formalized to identify such opportunities.
2. Consider use of group approach for other R&D projects in regions and industries made up of small companies.
3. Develop technologies applicable to joint treatment.

TO REGIONAL PLANNING AND REGULATORY AGENCIES:

1. Foster development of group solutions where applicable.
2. Enlist assistance of Chambers of Commerce and other trade organizations to provide information on group treatment alternatives.
3. Establish compliance schedules on a geographic basis to facilitate group solutions.

CHAPTER IV

TECHNICAL ASSESSMENT

The technical assessment required to meet the objectives of the study includes:

- Analysis of the pollution control problems facing the three firms, including the mutual problems caused by manufacturing operations, the unique problems presented by their location, and the physical statistics relative to each firm;
- The treatability of the process wastewater;
- The various concepts employed in development of a multicompany treatment facility.

The technical assessment provides the basis for the various economic considerations presented later in this report. Detailed information relative to each firm and potential group treatment is provided in Appendices A through D.

POLLUTION CONTROL PROBLEMS

All three firms are large producers of silverplated holloware. As one would suspect, the basic steps required to produce silverplated holloware from brass sheet stock result in many common wet process operations that produce similar wastewater. Obviously their location in Taunton, Massachusetts, presents each firm with common problems relative to meeting regulatory requirements. Many of the pollution control problems are unique to this location. This is important to understand when using the information in this report. In order to consider the concept of multicompany treatment of plating wastes for other areas, a description of each participating firm and its particular pollution problem is provided. These problems are subdivided into discrete problems, such as wastewater streams that are common to all three firms as well as unique to each one.

Common Features

Manufacturing Operations--

In the production of holloware, brass sheet stock is mechanically pressed into shapes which are then soldered to each other. The various decorative edgings, legs, handles, etc. are next soldered to items to produce the final shape of the finished part. Assembled parts are polished and buffed to obtain a highly reflective surface for finishing operations. The assembled parts are silverplated using cyanide solutions. In some cases an underplate of copper and/or nickel is employed. After plating, a final finishing operation is used to mechanically produce a product that is uniform in appearance.

Wet Processing--

The most common wet processing of parts is cleaning. Depending upon the particular production item, a given piece of metal may be cleaned as many as seven times from start to finish. Cleaning is employed in stamping and drawing steps, before and after annealing, before and after solder assembly, after polishing and buffing, prior to plating, and in some cases during final finishing. The alkaline cleaners used in these steps have been selected to result in a minimum attack on the base metal.

Strong acids are employed to remove annealing scales. However, the majority of acids used are only mildly corrosive to the base metal in order to maintain the appropriate surface finish. All firms employ either fluoboric acid or proprietary mild acid salts for surface activation prior to plating to minimize attack on the polished base metal and to satisfy the demands of the tin-lead alloys used for decorative and assembly objectives.

Cyanide copper plating is used to cover the parts with an initial plate, enhancing the adhesion of subsequent electrodeposits. Conventional acid nickel is plated onto some parts, either as a final finish or as a preplate prior to silver. Silverplating is done in conventional cyanide solutions using proprietary brighteners. Attempts to replace cyanide solutions with plating baths free of cyanide have not been successful.

As is common to other plating operations, a modest percentage of wastewater results from chemical stripping of plating fixtures, or racks, and the stripping of items for rework and salvage.

Combined Wastewater--

Another common feature for these three firms, which is not unique for older plants that were built and were expanded when concern for pollution control was minimal, is presented by the multiplicity of drain systems that combined process water with cooling water and sanitary wastewater. When these plants were built, the only concern appeared to be to remove all water from the plant. Wet processing is scattered throughout the plants and located to optimize material flow and is not located to centralize the wet processes--or their wastewater.

Water Waste--

Another common feature for these three firms which is also exhibited throughout the metal finishing and plating industry is the excessive use of water. When the cost of water was the only concern, and as it was initially a cheap commodity, production lines and plating practices were established wherein large quantities of water were employed in rinsing and cooling water applications. Excluding water used for sanitary purposes, the three firms used a total of 425,000 gallons per day. With the concern for water conservation, changes in the past several years have reduced this water consumption somewhat. Now, with the objective of minimizing water pollution control costs, further conservation effort became mandatory. A conservative reduction of 280,000 gallons per day can be realized for these three firms as they act upon recommendations.

Silver Reclamation--

As the value of silver has risen over the years, various efforts have been implemented by the three companies to minimize their losses to the sewer. The attention directed to these silver reclamation efforts naturally depended upon the quantity being discharged. For many years, spent process solutions that were high in silver content were shipped out for reclamation of silver values. In one case, where efforts to control pollution were initiated in 1972, silver reclamation was extended to include the sludges resulting from cyanide oxidation. At another firm, treatment of some rinses with metallic zinc to displace dissolved silver by cementation allowed for partial recovery of silver draining to the sewer. All firms have recently adopted electrolysis as a means of lowering the silver content in dragout recovery tanks--and thus reducing the amount of silver entering the rinse waters.

The total amount of silver reclaimed during the past 30 months amounts to 84,600 troy ounces (tr oz). This amount of silver reclaimed can not be readily related to dollars. The practice of all three companies is to ship the silver to one or more refineries. Credits for silver shipped are accrued at the refinery. Then, when the need for silver or silver salts exists, they draw upon their accrued account. For example, wastewater or sludges containing 1000 tr oz are shipped to the refinery. A credit for 1000 tr oz, less shipping, handling and refining costs, is credited to the firm. Then when a need for metal exists, it is requested from the refinery as so many tr oz of metal and/or so many tr oz of potassium silver cyanide. This approach is desired for accounting purposes and has proven beneficial during the climb in the value of silver as a commodity. In essence, the silver is still owned by the company even though it is in the hands of the refiner.

While attention has been paid to silver reclamation, which is on the increase, it is estimated that during the past 30 months they have lost 80,000 tr oz. With the installation of pollution control and with additional emphasis on reclamation, it is believed that 90 percent of this can be recovered. Efforts within the last six months have already salvaged 20 percent of the annual loss. When the pollution problems are resolved, recovery of 29,000 tr oz per year can be realized.

Wastewater Characterization--

The final common feature of the pollution control problem relates to the process water itself. All firms have water that can be segregated into:

- Waters resulting from alkaline cleaning which are mildly alkaline and low in heavy metals;
- Waters that are acidic and/or alkaline in nature which contain minor amounts of the heavy metals--copper, zinc, tin, lead and nickel (only two of the three companies for nickel);

- Waters that are strongly acidic and contain high concentrations of heavy metals;
- Cyanide-bearing water that invariably contains copper and silver.

Additionally, in two of the firms there are waters that essentially contain only suspended solids. Also, wastewater contamination levels increase significantly when spent or contaminated process solutions are dumped into the sewer.

Unique Problems in Taunton

All of the firms have ready access to sanitary sewers and to streams for discharge of their treated wastewater. Two of the firms might use the Mill River (see Figure 24, Appendix D). One uses the Taunton River. The Mill River, a tributary to the Taunton River, has no sanitary treatment facilities discharging into it. As a result, concern has been raised as to obtaining permission for discharge to the Mill River under the "antidegradation clause" of state law (see Appendix F, "Regulations for River Discharge"). Historically, both firms have used the Mill River and permission may be granted--if this becomes the preferred point of discharge for some wastewater. If the Mill River cannot be used, the discharges will be to the sanitary sewer.

Normally, pretreatment regulations for discharge to a sanitary sewer allow a firm to install treatment facilities that are less sophisticated than those required for discharging to a stream. However, a unique condition in Taunton results in more stringent requirements for sanitary sewer discharge than for stream discharge. The sanitary treatment facility presently being built (as described earlier in this report) has a relatively short retention time in the aeration chamber (less than two hours) where most of the BOD is removed. In addition there is a nitrification unit for advanced treatment. These processes are considered to be more sensitive to heavy metal contamination than other municipal treatment processes. Consequently, the maximum limits established by the local ordinance (refer to Appendix E, "City of Taunton Sewer Ordinance") for the metals from metal finishing and plating are very low.

The sludges resulting from the treatment of plating and other metal finishing wastewater are classified as "Hazardous Waste" (refer to Appendix G, "Solid and Hazardous Waste Regulations"). At the present time there are no approved disposal sites in the Commonwealth of Massachusetts. Those firms which have installed treatment facilities either are accumulating their sludges or are having them trucked to neighboring states. Recently one state has closed its borders to waste from out of state--just as Massachusetts prohibits wastes from other states from being shipped to within its borders. As a result, significant costs are resulting as the trucking distance becomes greater. The problem is expected to become more severe and disposal costs will increase before approved sites become available within practical shipping distances.

The final unique problem in this location is the water supply itself. In the past raw water supply by the municipality has been quite acidic. Values as low as pH 2.5 have been measured and 4 was quite common. In addition, the concentration of dissolved copper is high (2 mg/l is common and values as high as 7 mg/l have been recorded). At times heavy doses of chlorine have been required. At the low pH and in the presence of high concentrations of oxidizing agents, the corrosive nature of the water attacks the companies' water distribution system, the wet process equipment and cooling surfaces. As expected, this results in heavy metal contamination of the water before it receives an introduction of process chemicals. Fortunately, the City of Taunton is addressing its water supply problems and continual improvement is anticipated. As the water quality is improved, it is expected that the limits given in the sewer ordinance will become more strict than they are today.

Reed & Barton Silversmiths

A detailed description of the pollution control problems facing Reed & Barton Silversmiths is provided in Appendix A. To summarize the problems:

The company has been discharging during a single shift operation in excess of 220,000 GPD of industrial-use water, through seven sanitary sewer outlets, with all but one being combined with sanitary wastewater. Water is used in thirty departments located in twelve buildings. A significant problem is presented in the isolation and collection for treatment from these sources. The problem is compounded by the need to segregate the wastes for treatability purposes and magnified by the Mill River dividing the plant in half.

The process wastewater contains objectionable amounts of cyanide (including complexes of copper and silver) and the heavy metals copper, zinc, silver, nickel and iron. Lesser amounts of chromium, tin and lead are present, which will become of concern as water conservation efforts eliminate the dilution effect. Historically, the wastewater has been acidic. With the preponderance of alkaline cleaning and a minimum of acid processing, it would be expected that the wastewater would be near neutral or slightly alkaline. It is believed the acidic condition is as much a result of the quality of the raw water as it is of the metal finishing and plating processes employed.

Poole Silver Company

A detailed description of the pollution control problems facing Poole Silver Company is provided in Appendix B. To summarize the problems:

The company has been discharging during a single shift operation in excess of 33,000 GPD of industrial-use water combined with additional sanitary wastewater. The collection, isolation and segregation problems are not as complex as at Reed & Barton. However, unlike Reed & Barton, Poole has no land available for expansion to install treatment facilities. Poole Silver Company will have to use a storm sewer if discharging to the Mill River.

The process wastewater contains objectionable amounts of cyanide (including complexes of copper and silver) and the heavy metals copper, zinc and silver. Lesser quantities of iron, tin and lead are present. Again the pH of the discharge is a reflection of the raw water quality, although a slightly higher ratio of acid to alkali process water is noticed when comparing with the other two companies.

F. B. Rogers Silver Company

A detailed description of the pollution control problems facing F. B. Rogers Company is provided in Appendix C. To summarize the problems:

The company has been discharging during a single shift operation in excess of 130,000 GPD, with 40,000 GPD entering the Taunton River under an NPDES permit and the rest via three connections to the sanitary sewer, two of which are mixed with sanitary wastewater. Unlike the other two firms, this company has been treating wastewater discharging to the river and pretreating most of its wastewater discharging to the sanitary sewer. As with Poole Silver Company, this firm has no adjacent land to use for additional treatment facilities.

The untreated process wastewater contains objectionable amounts of cyanide (including complexes of copper and silver) and the heavy metals copper, zinc, silver and nickel. Lesser amounts of tin and lead are present. The most pressing problem facing F. B. Rogers is the necessity to upgrade its existing treatment facilities in facing the more exacting limits established by new regulations.

TREATABILITY OF WASTEWATER

The need to treat (or pretreat) process wastewater resulting from metal finishing and electroplating has been well documented in the literature. Likewise, the multiplicity of wet processes in use, together with the unique treatment(s) required by some, is well described. It is not our intent to repeat all of this information as it is readily available to those who wish a detailed description. However, it is our desire to provide a brief description of the treatability concepts used as a basis for subsequent design concepts.

Heavy metals found in the process water are predominantly copper, zinc, silver and nickel. Lesser quantities of tin, lead, iron and chromium are to be found. Trace quantities of tellurium, mercury and gold are seen on occasion. Most of these metals are as dissolved salts. The treatment concept employed is to reduce the metal solubilities to a minimum level by precipitation as the hydroxide or oxide, or other insoluble salt (silver chloride for example). Where possible and practical, isolated treatment for a single metal will be employed. The greatest volume of wastewater contains many of the metals in combination. As each metal has its specific pH for minimum solubility, some of which are outside of the prescribed pH range for acidity and alkalinity, those most critical metals from a toxic standpoint will dictate the pH employed for control.

Cyanide is found in the process wastewater as potassium and sodium cyanide and as complexes with copper, silver and gold. Isolation for treatment purposes will also keep the cyanide from complexing with iron and nickel found in other waste streams. Consequently, the amount of cyanide that is not amenable to chlorination is held to a minimum. The two step oxidation method is preferred over the single step to reduce the incidence of hydrolysis of cyanate to form ammonia. Due to the low levels prescribed for copper, the presence of ammonia could interfere with efficient copper removal.

Alkaline cleaners used in the silverware industry, by the nature of the parts being cleaned and the soils involved, are considered to be mild in nature. Where contamination with oil or grease is experienced, invariably vapor degreasing precedes the alkaline cleaning. The cleaners have been designed to have a minimum attack on the base metal. Consequently, chelating agents, selected to solubilize heavy metal surface films are not common. The stronger alkalines, common to the metal finishing industry where steel is the base metal, are not employed. With a milder alkali and with a minimum of additives for solubilized metals, a heavy dependency upon detergents and other wetting agents results. For example, the rinse waters after these cleaners are notably low in heavy metal concentration (see Appendix A, Table 8 SSO #9, which is 90 percent cleaner rinse water). Spent alkaline cleaners have the same general characteristics as their rinse, but at a higher concentration. Neutralization of excessive alkalinity produces wastewater that is compatible with the biological treatment offered by sanitary sewerage systems. The wetting agents, on the other hand, interfere with the removal of heavy metal hydroxides and oxides when present in excessive amounts. In addition, they are considered to be toxic to aquatic biota. In general, the wastewater from alkaline cleaning is comparable to that found from dishwashers, laundry waste or other high detergent-containing waters. The ideal treatment for these rinses and spent cleaners is the sanitary sewer. To preclude shock loading, the batch dumps should be metered into the sanitary waste discharge at a low and controlled rate.

As the future requirements for treatment quality have yet to be fully developed, it is felt that the best practical treatment limits as presently interpreted should be used for the purposes of this feasibility study. Where state and/or local regulations stipulate values that are lower than federal guidelines, these lower levels are used as treatment objectives. Condensations of these regulations are to be found in Appendices E, F and G.

CONCEPTS

The concepts considered under this study include each firm treating its own wastewater; group treatment of combined wastewater, in total or in part; and extension of group treatment facilities to include other firms having similar wastewater. In addition, considerations have been given for recovery values for salvable metals, techniques for enhancing the values as volume expansion permits, and new technology having potential merit.

Detailed descriptions of facilities for each plant are provided in Appendices A, B and C. Those identified as Primary Design consider each plant being required to treat its own waste separately and form the basis for comparison of alternatives. In addition, the impact caused by discharge point (sanitary sewer vs stream) is described. The advantages of reusing treated process water are brought forth. A description of joint efforts is provided in Appendix D. In considering expansion of joint treatment effort, some alternatives discussed for the companies include concentration of rinse waters. The economic assessment of the many alternatives is provided in the next section of this report.

ASSESSMENT

From an overall viewpoint it appears that the best interest of the firms and the total environment will be served by each plant treating its own flowing rinse waters and by combining the firm's efforts for treatment of the batch wastes resulting from the dumping of spent process solutions, from accidental discharges, and waste treatment operation resident for each plant. Additional benefits can be gained by concentration of selected rinses for subsequent batch treatment. The values for salvable metals are greatly improved by the joint venture.

The primary reason for the negative results of joint treatment of flowing rinses receiving comparable treatment is the distance between plants and the cost of piping and pumping. If the companies were closer together, the economics would change. Since the cost of some of the major treatment components is directly related to their capacity, the savings gained through centralized treatment are minimal. However, other components (control systems for example) would not be duplicated if centralized treatment were selected. As a result, a net reduction in capital cost close to 10 percent would be possible. As it is, however, the costs of group treatment of rinses for these three firms is not attractive.

From a technical and economic view, the ideal discharge points appear to be a combination of stream and sanitary sewer discharge. The unique conditions in Taunton may not be as applicable to other locations. Normally, the quality requirements for discharge to the sanitary sewer are less demanding than for stream discharge. The more restrictive limits of the sewerage system result in the reverse being true for these firms. For example, the need for final filtration to upgrade the stream discharge will probably not be required until 1983. However, it is required prior to sewer discharge in Taunton.

The degree of treatment provided to meet the various regulations results in a water quality that is sufficient to allow reuse of significant quantities of water. Obviously, reuse of the treated process water for plating baths is not reasonable due to the possibility of trace metal contaminations. Likewise, final rinsing should receive the highest quality water to minimize stains caused by dissolved salts during drying. Yet many, less demanding, applications for reuse water can be found in cleaning, pickling and stripping, to mention a few. Economic analysis indicates that substantial cost reductions can be realized through water reuse.

Only evaporative recovery has been considered for potential application in the concept of eliminating certain rinse treatment systems by concentration. Reverse osmosis is not believed to be at the commercial stage for cyanides because of the high pH, or for the pickles employed where lead is present (both shorten the membrane life). It could have been considered for nickel plating at F. B. Rogers Silver Company but was not because the firm had installed ion exchange equipment several years before reverse osmosis was commercially applicable.

One of the firms visited outside of the three principal companies was Sheffield Silver Company in Norton, Massachusetts. This subsidiary of Reed & Barton Silversmiths has installed evaporative recovery equipment along the lines suggested in Alternative B-2 for Poole Silver Company. Primarily, the rinse water is recovered. Facilities for treatment of cyanide rinses using flow-through processes have not been installed (although chemical batch treatment has been provided as backup for the evaporator). The concentrate from the evaporator is held for reclamation of metal values. A recent analysis of the concentrate showed:

potassium cyanide	80 gm/l
silver	33 gm/l
copper	13 gm/l

The volume and quality of the concentrate from Sheffield is believed to be close to that which would result from Poole's comparable application. Similarly, the other company considered for secondary evaluation as a potential group member was the Poole Silver Company plant in Fall River. A pretreatment program, however, has required installation of equipment to meet another set of metallic limits. It is assumed, however, that batch discharges from the Fall River plant could be handled in a group facility in a manner similar to that at the Taunton plant.

The advantages of group treatment that will influence any decision to proceed include:

1. Cost reductions will result from bulk purchases of treatment chemicals that would not otherwise be available for each firm acting independently.
2. More efficient sludge handling facilities can be applied for all firms with a reduction in disposal costs anticipated.
3. Batch treatment equipment will receive greater utilization by expanded capacity, resulting in a lower cost per unit treated.
4. Technicians will expend a greater portion of their time on batch wastes and, in doing so, will become more skilled, thus enhancing environmental quality.
5. The extramural support (analysis, assay, consultation) for the single facility will be less than were each treated separately.

6. The net salvage values received from refiners for silver, after deducting processing costs, will be higher.

7. Salvage potentials for copper and nickel become more practical as the amount involved increases by multiple company efforts.

8. More efficient reclamation methods can be justified by joint action than for each independently. The potential for separating copper and silver from mixed cyanides carries with it certain development expenses than can be amortized over expanded use.

9. Electrolysis of concentrated cyanide solutions as proposed for the joint treatment is approximately 15 - 20 percent of the operating cost required by chlorination. This capital intense process requires a minimum quantity of batch cyanide wastewater to justify the greater cost to buy and install, than existing with chlorination techniques.

10. As the problems relating to solid waste disposal become resolved, costs will escalate. Disposal in bulk will reduce expenses to all firms.

It can be concluded that both the environment and the firms involved themselves will benefit from group treatment of batch wastewaters. The information on the economics to support this conclusion follows in the next chapter.

CHAPTER V

ECONOMIC ASSESSMENT

The assessment of economic considerations included the capital investment and operating expenses for: each plant providing its own complete wastewater treatment facilities with multiple discharge points; various alternatives for each company; group treatment of the three companies' wastewaters; expansion of the group treatment concept to include other firms; and recovery values. The data summarized in this section are explained in detail in Appendices A through D.

Two economic factors have not been included in this assessment. Depreciation of equipment depends upon judgment factors and upon tax incentives. The other economic factor applies to the concept of "cost of money," wherein annual expenses are attributed to having one's capital tied up in nonproductive facilities. At the present time, the "cost of money" is in the 8 to 10 percent range. The reader is left to apply these two factors to annual operating expenses as desired.

THREE SEPARATE FACILITIES

As a basis for comparison of alternatives and potential joint treatment of wastewater, the following data are presented for each firm. Included for Reed & Barton Silversmiths and Poole Silver Company are the economic impacts of not being able to use the Mill River for discharge of part of their treated wastewater; then total discharge would be required to the sanitary sewer. The economic advisability of reusing treated wastewater is shown for each firm.

Reed & Barton Silversmiths

The economic data in Appendix A are summarized in Table 1. As shown the Primary Design--using complete treatment of some rinse waters prior to stream discharge and pretreatment of other rinse waters prior to discharge to the sanitary sewer, together with batch treatment--will require a capital investment of $640,500 and result in an annual operating expense of $138,595. A modest reduction in operating expense will result from partial reuse of treated waters. If stream discharge is prohibited, expenditures increase by 15.8 percent for capital and 27.8 percent for operations. Under the total discharge to the sanitary sewer concept, the savings by reuse of treated water are much greater and show a 13-month return for additional invested capital required for reuse of the treated water.

TABLE 1. REED & BARTON SILVERSMITHS - SUMMARY OF ALTERNATIVES*

	Primary Design	Alternative 1	Alternative 2a	Alternative 2b	Alternative 3
Capital					
Equipment	$316,000	$384,300	-	-	-
Installation	158,000	170,000	-	-	-
Value of Space	121,500	142,900	-	-	-
Engineering	45,000	45,000	-	-	-
Total Capital	$640,500	$742,200	$650,500	$752,200	$484,500
Operating Expense					
Labor	$ 89,200	$102,600	-	-	-
Energy	3,250	4,690	-	-	-
Chemicals	23,000	27,200	-	-	-
Supplies	4,000	6,500	-	-	-
Sludge Disposal	8,250	9,700	-	-	-
Sewer Charges	5,895	22,857	-	-	-
Extramural Support	5,000	5,000	-	-	-
Total Annual Operating Expense	$138,595	$178,547	$136,225	$167,280	$145,995

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*Primary design: Rinses to sanitary sewer and river plus batch treatment.
Alternative 1: Rinses to sanitary sewer plus batch treatment--no river discharge.
Alternative 2a: Primary design with reuse of treated water.
Alternative 2b: Alternative 1 with reuse of treated water.
Alternative 3: Rinses per primary design, collect batches for contract disposal.

The data shown for the design that considers elimination of batch treatment facilities may be misleading if used out of context and compared with subsequent information concerning group treatment. Certain discrete components would be required for rinse water treatment which might be used also for batch treatment. Since their common use is practical at a common treatment site located at Reed & Barton, the capitalization and operating expense should not be duplicated, but rather prorated as to use by each system. Caution must also be expressed for the somewhat small increase in operating expense when comparing this alternative with the Primary Design. The costs for contract hauling and disposal reflect present economics. As the regulations governing this cost become fully developed, it is believed that the disposal costs will increase drastically as the cost of disposal is passed back to the generating source. One source questioned anticipates a 1,000 percent increase over current rates.

Poole Silver Company

The economic data in Appendix B are summarized in Table 2. As shown in previous firm, the most attractive alternative considered a dual discharge (i.e., stream and sanitary sewer). This Primary Design is expected to require a capital investment of $141,000 and result in an annual operating expense of $37,977. If stream discharge is prohibited, expenditures will increase by 13.7 percent for capital and 34.0 percent for operating expense. Again, reuse of treated water is advisable--although the rate of return for additional invested capital is lower than for the previous firm, as the potential for cost reduction is smaller with only a portion of the available water being used.

As with the previous company, the concept that eliminates batch treatment contains the same probability for escalated disposal costs for collected batch wastes. At Reed & Barton some of the equipment used for treating rinses finds utilization in batch treatment. However, for Poole Silver transfer of batch treatment operations to another location does not significantly reduce capital investment (less than 5 percent reduction).

Poole Silver Company is presented with an option to replace a segment of its rinse water treatment system with evaporative recovery. There is little difference in capital investment. Operating expenses increase approximately 10 percent--primarily because of higher energy requirements.

F. B. Rogers Silver Company

The economic data in Appendix C are summarized in Table 3. This company has completed its capital investment for a major portion of the waste treatment facility during the past three to four years. The capital values shown are what one would expect to invest at today's market conditions and do not necessarily reflect actual expenditures in the past. In addition, certain unique conditions that caused higher than normal expenses have not been included

TABLE 2. POOLE SILVER COMPANY - SUMMARY OF ALTERNATIVES*

	Primary Design	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Capital						
Equipment	$ 73,200	$ 88,100	$ 86,900	$114,200	$ 71,300	-
Installation	32,000	34,500	25,000	30,000	30,000	-
Value of Space	25,800	27,800	18,600	18,600	25,400	-
Engineering	10,000	10,000	10,000	10,000	10,000	-
Total Capital	$141,000	$160,400	$140,500	$172,800	$136,700	$146,000
Operating Expense						
Labor	$ 18,780	$ 26,580	$ 18,780	$ 18,780	$ 17,840	-
Energy	1,994	2,099	14,454	14,152	1,984	-
Chemicals	8,500	10,600	1,850	8,500	8,000	
Supplies	1,000	1,200	1,000	1,000	950	-
Sludge Disposal	980	2,150	980	980	2,680	-
Sewer Charges	2,223	3,838	2,726	1,727	2,223	-
Extramural Support	4,500	4,500	4,500	4,500	4,500	-
Total Annual Operating Expense	$ 37,977	$ 50,967	$ 42,290	$ 49,639	$ 38,177	$ 36,397

*Primary design: Rinses to sanitary sewer and river plus batch treatment.
Alternative 1: Rinses to sanitary sewer plus batch treatment--no river discharge.
Alternative 2: Primary design with evaporative recovery for cyanide rinses.
Alternative 3: Primary design with evaporative recovery for pickle rinses.
Alternative 4: Rinses per primary design, collect batches for contract disposal.
Alternative 5: Primary design with reuse of treated water.

TABLE 3. F. B. ROGERS SILVER COMPANY - SUMMARY OF ALTERNATIVES*

	Primary Design	Alternative 1	Alternative 2	Alternative 3
Capital				
Equipment	$139,500	-	$136,500	-
Installation	74,000	-	72,500	-
Value of Space	63,000	-	61,800	-
Engineering	18,000	-	18,000	-
Total Capital	$294,500	$299,500	$288,300	$299,500
Operating Expense				
Labor	$ 23,500	-	$ 23,270	-
Energy	1,500	-	1,390	-
Chemicals	14,200	-	13,700	-
Supplies	1,500	-	1,500	-
Sludge Disposal	1,800	-	16,020	-
Sewer Charges	7,700	-	7,700	-
Extramural Support	4,500	-	4,500	-
Total Annual Operating Expense	$ 54,700	$ 49,200	$ 68,080	$ 52,450

*Primary design: Rinses to sanitary sewer and river plus batch treatment.
Alternative 1: Less to sanitary, more to river.
Alternative 2: Rinses per primary design, collect batches for contract disposal.
Alternative 3: Primary design with reuse of treated water.

so that the overall picture will be more representative of the average plant yet to face its pollution problem entirely. (For example, with normal high tide in the adjacent Taunton River being 12 to 18 inches below the plating room floor level, high expenses were realized in installing five-foot deep sumps used to collect wastewaters.)

The design approach employed for the Primary Design was similar to that used for the other two firms, except that it was influenced by earlier design concepts that resulted in the existing facilities. Since the present river discharge is being influenced by the existing upgrade efforts, it was felt that initially little attention should be directed toward increasing the facilities used for river discharge. As a result, the Primary Design is not considered to be the most attractive alternative. Alternative 1 shows a modest (1.7 percent) increase in capital expenditure which is returned the first year through reduced operating expense. By being located adjacent to the Taunton River, F. B. Rogers Silver Company does not have to consider final filtration at the same time as the other two firms may have to if Mill River discharge is not permitted. The previously discussed "antidegradation" clause does not apply to this location.

Under Alternative Design 1 a greater portion of the wastewater containing heavy metals is diverted to the river discharge. Capital expenditures are valued at $299,500 and an annual operating expense of $49,888 is expected. Using this concept, little economic advantage is realized through reuse of treated process water.

Again, the design that uses contract hauling in place of batch neutralization is factored for disposal costs that are not expected to remain at the present price. Much of the batch treatment equipment required for complete in-plant treatment is already installed. Consequently, cost avoidance is much lower for this firm. The greatest advantage to this company of using group treatment facilities will come from reduced operating expenses and improved silver recovery.

GROUP TREATMENT

The economic assessment for group treatment efforts considers that each plant will install its own treatment facilities for flowing rinses and that batch wastes will be treated at Reed & Barton. It is not practical within the scope of this study to factor all the possible permutations presented by the various alternatives. Rather, the most practical combinations, and those that are most likely to occur, are used for the economic assessment of group treatment.

For the purposes of quantifying the various cost factors, that portion of Reed & Barton's facilities used for batch treatment is identified as though the group treatment facilities were a fourth identity. Those items that are used by both rinse water treatment and batch treatment have been prorated to each system as an aid to quantifying this option.

Capital Expenditures

The capital expenditures listed consider that each firm will treat its own flowing rinse waters at its respective plant; that collection facilities will be provided for segregated batch wastewater and residual wastes from their treatment facilities; that stream discharge will be permitted for each firm; that there will be maximum utilization of treated wastewater; and that batch wastes will be treated at Reed & Barton.

With the same four capital factors as used previously, the capital expenditures for each company to treat its rinse waters will be:

Reed & Barton Silversmiths	$484,500
Poole Silver Company	$141,600
F. B. Rogers Silver Company	$293,300

with the joint batch treatment facilities being located at Reed & Barton

Joint Treatment Facilities	$173,900.

The total capital expenditure amounts to $1,093,300 and should be compared with the capital required for each company to install its own complete facilities ($1,096,000). Within the accuracy of cost analysis, these two figures indicate that there is no capital advantage one way or the other.

Operating Costs

Using the same basis as applied for capital expenditures, the annual operating expenses will be:

Reed & Barton Silversmiths	$100,900
Poole Silver Company	$31,900
F. B. Rogers Silver Company	$44,300
Joint Treatment Facilities	$41,300

Comparing this with the expenses anticipated at each plant if totally treating its own waste, a modest saving of $3,000 per year is expected. This does not include depreciation of equipment and the cost of borrowing, as previously discussed.

Cost Variations

The various cost reductions listed in Chapter IV which result in group treatment efforts for batch waste reductions can be quantified.

Sodium hydroxide, in bulk shipments, will cost approximately 50 percent of the price in drum lots. Sludge disposal rates will gain by bulk shipments, which are priced at $0.13 per gallon versus $0.40 per gallon in drum lots. It is also expected that the volume of sludge will be reduced by the more sophisticated handling facilities. Sludges with a solids content of 20 to 25 percent will result, as compared with 5 to 7 percent. This will result in approximately one fourth the amount requiring disposal.

Greater utilization of equipment used for batch treatment will reduce cost factors of equipment depreciation as applied, for each gallon treated will be approximately 50 percent. Extramural support will be reduced by approximately $4,000 per year. This primarily relates to insuring quality of sludges. Other cost variations relative to reclamation are discussed later in this section of the report.

Cost increases will result from transportation from Poole Silver Company and F. B. Rogers Silver Company to the Reed & Barton site. These costs are budgeted at $3,000 per year.

EXPANSION

The expansion of group treatment efforts will depend upon normal market conditons. Major costs are attributed to the treatment of flowing rinse waters, with far less capital involved in treating batch wastes. Poole Silver Company is a good illustration when considering expansion of group treatment to include other companies. Capital avoidance will exist; reduced operating expenses can result. It is not practical under the scope of this study to quantify group treatment expansion in more than the broadest sense.

Expansion is possible without any increase in capital investment. The facilities included in the joint batch waste treatment operations are not used 100 percent of the time. The various subsystems have been sized to maximize labor use. This results in some of the equipment being underutilized. As the amount of batch waste to be treated is expanded, only the direct expenses of labor, energy, chemicals, supplies and sludge disposal will increase. When the cost factors that consider applied overhead and depreciation of equipment are prorated across each individual batch being treated, then the cost per batch will decrease according to the total volume under any expansion concept.

The facilities considered to be a minimum for the three firms as described earlier have built-in expansion factors of 40 percent for batch acids, 20 percent for batch cyanides, and 80 percent for metal reclamation before any additional capital investment is required--other than larger storage facilities for raw waste.

RECOVERY VALUES

The previous assessment of economic conditions does not show an overwhelming advantage of group treatment to produce acceptable water and sludge discharges to the environment. Attention has been focused on pollution control itself. Cost advantages do exist relative to the discharge of residual sludges resulting from waste treatment practices. Where recovery of metal values exists, a decided advantage can result from use of more sophisticated facilities than can be justified for only the large plants. In the case of the three firms involved in this project, the primary consideration for metal recovery is silver. If the volume increases, copper and nickel should be considered.

The subject of silver losses has been discussed in Chapter IV. The economic information discussed previously has been limited by the exclusion of information on silver reclamation and deals solely with nonrecovered wastes or those with little value. The sludges discussed so far have had insignificant silver concentrations. The treatment systems themselves, while segregating silver-bearing wastes, have been essentially directed toward providing acceptable water quality. Since reclamation has a major role in the economics of group treatment, it has been retained as a separate item.

Silver reclamation for these companies is extensive. Particulate matter removed from dust collection systems is shipped out to refiners for reclamation. Some solutions known to be high in silver are returned to vendors for reclamation. Metal scrap is salvaged for silver content. Additional salvage values will result from processing waste treatment residuals.

Approximately 995 kilograms (32,000 tr oz) per year have been lost to these three firms during recent years, having an average value of $145,000. It is believed that 90 percent of this loss could be recovered through the waste treatment systems and metal reclamation proposed. Electrowinning from dragout recovery tanks has recently been put into use, with recovery approximately 20 percent of this annual loss and with the product resulting being essentially 100 percent silver. The remaining 800 kilograms (25,600 tr oz) will discharge to the waste treatment system. Of this amount, 90 percent is considered to be a minimum that can be recovered via the waste treatment systems. Most of these recovered values will come from sludge.

In order to fully appreciate the potential for recovery, it is important to understand the present-day economics of silver reclamation. As one would suspect, the higher the purity of the waste shipped out for refining, the lower the refining or salvage charge becomes. Refining charges as low as $0.012 per gram ($0.38 per tr oz) have resulted from high-purity waste. When sludges mixed with other solids and water are shipped out for reclamation, the charge for recovery is normally $1.23 per kilogram ($0.56 per pound) of sludge processed, based upon a set weight. Depending upon the concentration of silver in the wet sludge, the recovery costs can exceed the value of the silver--with a total loss of silver values. Obviously, efforts to enrich the sludge will be beneficial. Under average conditions during the past eighteen months, approximately 25 percent of the silver values have been returned to the producer, with the remaining 75 percent being lost to reclamation charges. Under the waste treatment systems proposed for the group treatment project. it is believed that the 75 percent loss will be reduced to 15 percent. Further refinement may result if the concept of separating copper from silver proves to be viable. The net result of the waste treatment efforts that are directed towards silver recovery for these three firms will return approximately $130,000 to them collectively on an annual basis. This is in addition to, and about equal to, the amount presently being recovered.

Two other metals, copper and nickel, have potentials for salvage should the volume become larger through expanded use at the treatment facility. At today's prices, nickel will bring $1.76/kg ($0.80/lb) in solution form and $0.77/kg ($0.35/lb) in sludges. These values will be reduced by the costs of shipment and should be considered only when concentrations are high enough and volumes warrant bulk transportation. Copper in solution form can bring $0.88/kg ($0.40/lb), subject to the same conditions.

ASSESSMENT SUMMARY

As discussed earlier, when considering waste treatment costs to resolve environmental pollution problems alone, significant dollars are involved. For these three companies, there appear to be marginal advantages to group treatment of process wastes. However, when including the recovery values for reclaimable metals, the annual operating expense is reduced from $218,000 to $88,000. The full cost reduction can be realized by group treatment. It is believed that the added expense to each firm to implement individually the recovery aspects will consume at least half of these savings.

In the introduction to this section, two economic factors were excluded--depreciation and "cost of money." To fully appreciate the advantage of increased utilization when applied to the batch treatment system, these factors should be included. Assuming ten-year useful life for equipment, the depreciation on a straight-line basis for the group treatment facilities is $17,390 per year. At an 8 percent cost of money, an additional $13,912 per year is realized. The total, $31,300, must be spread across the total volume of waste processed. If spread evenly, this will amount to approximately $0.16 per gallon of waste processed. All other operating expenses for the group batch facility have been listed as $41,300, or $0.21 per gallon processed. The total is $0.37 per gallon. Obviously, some process solutions require a higher share of these costs than others, but averages can show the advantage of greater utilization. Depreciation and "cost of money" represent 43 percent of the treatment expense with maximum utilization by these three firms. With less use, as caused by each providing its own batch treatment facilities, this 43 percent expense climbs. By a similar consideration, increased utilization is possible by expanding the joint facility to include other firms, which will result in a lowering of this cost per gallon from $0.16 per gallon to less than $0.10 per gallon.

In spite of the variable cost factors evaluated in this chapter, group treatment does have an advantage when metal recovery economics are considered and disadvantages related to individual company treatment operation are fully appreciated.

CHAPTER VI

INSTITUTIONAL/FINANCIAL ALTERNATIVES FOR MANAGEMENT

INTRODUCTION

Industry has traditionally looked upon government-imposed requirements, whether in the safety, health or antipollution fields, as imposing costs on the normal operating costs of the business.

Waste treatment is perceived as imposing three kinds of costs on the enterprise: first, capital costs for equipment; next, operating costs; and finally, costs of management's time expended on the waste treatment problem.

While there are public benefits to be derived from a more wholesome environment, some of the steps which must be taken to conform to the requirements of the law with respect to waste treatment may directly benefit business operations as well, with a resultant increase in profits. This fact arises because the process of installing an effective waste treatment system involves the optimization of plant operations, always a goal of industrial managers. The principal areas of such rationalization are water reuse and recovery of usable materials.

Balancing these benefits against costs can result in a considerable lowering of net costs to the business. Furthermore, it may be possible to spread capital and operating costs among several users of a waste treatment process through sale of services to outside companies who do not have space for pollution control or who could otherwise benefit. There are other potential benefits in the form of tax-exempt revenues.

While waste treatment may involve some technologies which are different from those currently employed by the particular business, the processes of tracking waste flows, analyses of contents, and amounts of recovered materials are really accounting operations, which will not be unfamiliar. There are, however, enough unfamiliar issues associated with complying with environmental regulations by means of group treatment that a review of the basic choices can be useful.

GROUP WASTE TREATMENT

The expanding of waste treatment into a multibusiness service offers certain advantages which improve the cost situation for each participant. It is possible to use sophisticated laboratory equipment for analyses, where an individual firm might not be able to bear the expense. Treatment equipment can be used more intensively at a group facility and group laboratory facilities may also be possible. Capital equipment cost may, in the aggregate, be high enough to justify tax-exempt industrial revenue bond financing. In Massachusetts such bonds may be issued by local industrial development financing authorities; they provide companies with the means of financing appropriately certified pollution control equipment at potentially lower cost than would be the case with other financing methods. Companies which lack required space, or technological knowhow, to establish their own treatment process can meet EPA requirements by purchasing services from a group treatment source. Companies not now on sewer lines would be able to transport wastes to the treatment source for later disposal into the municipal sewer system.

Group waste treatment depends on more than technological and financial considerations, however. It must rest on cooperation among industries which may compete with one another. And this cooperation must survive the passing of initial enthusiasm and be able to endure. The heavy investment in equipment, the prospect of ever more stringent rules to protect the environment, and the lack of alternative methods of waste treatment mean that the participating companies must be prepared to remain associated for many years. This places a special emphasis on the careful design of the institutional arrangements for group treatment. Not only must each participant be satisfied, but the arrangements must be durable.

There are several difficulties in creating a structure for group treatment. Participating companies may be very different in size and in market share. The ownership may differ; in some cases there may be family ownership or control, others may involve public ownership, and yet others may be subsidiaries of holding companies. The ownership pattern may affect attitudes toward cooperation with like industries.

There may be proprietary processes in some companies which would be revealed to competitors by group waste treatment. Some companies may already have invested in waste treatment equipment and may perceive few benefits for them if they participate. Companies may also differ in their aversion to risk--that is, in their willingness to put their waste treatment processes in the hands of outsiders.

Products and processes change with time, perceptions of corporate missions may also change and a company may leave one business to enter another. These normal business occurrences can introduce strains into the joint treatment structure. In addition, a group treatment scheme ought to be open to participation by companies not initially involved, provided that there is sufficient capacity in the system and the participation makes economic sense to all concerned. Any institution created to carry on group waste treatment must, therefore, be designed to be both durable and flexible. Once established, it should not be able to be too easily dissolved; yet it must allow adjustment of ownership shares and the admission of new members.

Ownership: Single or Group?

A basic question is whether the group aspect should be limited to use of the waste treatment processes or be extended to ownership of the facilities themselves.

Single Ownership--

There are several consequences of a decision to go ahead with a single-ownership institution.

Control--Single ownership means that control of processes and policies depends upon one company only, with its relationship to other participants regulated by contract. Some companies may feel that this places them, as nonowners, too far from control, that they can only react to decisions after they are made and can have no part in the making of the decisions themselves. Since waste treatment is a requirement of the law, with the risk of significant costs if not carried out, it is possible that participants may wish to exercise the greatest degree of control possible at all stages. On the other hand, single ownership may mean speedier decisions, and it could be argued that the likelihood of decisions having an adverse impact on participants is remote. Furthermore, contracts can be written which anticipate most risks.

Risk--Single ownership places a substantial burden of risk on the owning company; the risks are that of failure of the system to perform its task adequately, with consequent legal liabilities, and that with respect to the financing of the equipment. A question arises as to whether the owner would be willing to assume the risk of costs imposed on the nonowning participants if the system should be out of order for a period of time. Would the owner be willing to commit himself to pay costs of storage of wastes? Would it pay fines on behalf of participants who dump untreated wastes? These matters and others could be dealt with in contracts if single ownership were preferred.

Sharing of Capital Costs--Costs of process equipment can be heavy; on the other hand, if one participant's prospective use of the equipment is considerable, that company may be willing to assume the entire capital cost involved. Later attempts to recover some of the capital costs from users become complicated because of the need to establish a firm basis for computing the amount of payback and the time period over which it is to be accomplished. Contracts would have to establish a minimum time period for participation of payments to ensure correct calculation of capital recovery; otherwise, there is no guarantee to the single owner that it will recover a certain part of its equipment costs from outsiders.

Financing--Financing is easier when a single owner is involved. The prospective borrower may be able to get a commitment from his bank based on past satisfactory relationships.

Taxes--Single ownership would result in contracts for services so that the costs of the contracts can be written off against profits as costs of operation.

Group Ownership--

Financing--Financing presents a problem if individual companies seek group financing for a project. It is questionable whether tax-exempt bond financing is a practical alternative in such a case. There would have to be a separate issue for each company, and it is possible that the costs of separate issues may be so heavy as to outweigh the benefits of this form of financing. A bank loan would probably not raise substantial difficulties, however.

If companies combine to form a corporation to own and operate the waste treatment business, either bond or bank loan financing may be used without difficulty.

Control--Group ownership allows for each company to have a measure of control over the policies of the waste treatment business. Participants would trade off the ease of the user contract for the added control; it is likely that most companies would regard this as an acceptable trade.

Legal Form--There is a variety of possible legal forms for an institution set up for group ownership; these include the corporation, a trust, and a partnership. When the latter two are chosen, it is usually for reasons which have little relation to the waste treatment situation, and most companies with group ownership would choose the corporation as the most practical form. A partnership is probably too flexible and does not present adequate means of limiting members' liability. A trust would insulate the members from control to some degree, probably an unacceptable condition. A separate corporation does create difficulties in the management sphere. Since group waste treatment processes are physically on the premises of one participant (at least), operations and management must be severed from those strictly concerned with manufacturing. It is possible that the same personnel may have separate responsibilities both in the waste treatment and manufacturing areas. This may affect the management structure.

Adjusting of Shares--Group ownership raises the question of how the share of ownership can be adjusted to reflect changes over time in anticipated use of facilities. For example, an owner may be acquired by another company and may, as a result, find himself changing processes and products or under orders to install his own waste treatment equipment. Again, the corporate firm with shares held by participants appears to offer maximum flexibility; there can be agreement among shareholders for orderly procedures for withdrawal from, or change in participation in, the group waste treatment process. The same applies, of course, to admission of outsiders. They can be required to purchase shares in such a way as to distribute equitably the remaining capital costs.

Relations with Others--The waste treatment business will be subject to inspections from town and state officials; materials and services will have to be purchased, and there may be a public relations aspect as well. Thus the question arises as to who speaks for the business when there is joint ownership. If facilities are located principally on one owner's premises, and that company's purchasing department issues purchase orders, suppliers will look to that company for the fulfillment of the contract. Again, management of the host company will be closest to the process and will be more subject to contact with inspectors than the other participants. This may be acceptable to some companies; others may wish to insulate themselves through the creation of a separate corporation.

Risk--The risks which have been alluded to under the section on single ownership may be perceived as substantial by companies. Group ownership via a corporation would permit the apportioning of some of these risks according to the percent of ownership.

Financing--The possibility of looking at waste treatment as being associated with the general optimization of plant operations has been mentioned, with particular reference to the areas of water reuse and recovery of materials. The possibility of sale of services to outside businesses has also been noted. Each of these activities may affect the financing structure of the waste treatment business, should the participants desire to use tax-exempt bond financing. The IRS will not allow tax-exempt treatment for that portion of bond financing which is devoted to equipment used to create or improve profits. That has been interpreted to include recovery of materials for which a company receives credit and also reuse of water since that lowers water costs--on occasion, dramatically. Only the equipment used to meet antipollution requirements is able to benefit from tax exemption.

This gives rise to two problems. First, it is not easy to determine just where the dividing line is to be drawn--and hence, to determine how much tax-exempt bond funding to go for (assuming that this is the preferred financing alternative). The company may draw the line in one place, the IRS in another. Furthermore, the bond purchaser will wish to be assured that the IRS will not question the tax-exempt status of the bonds after they are bought. It is therefore necessary either to be ultra-conservative in drawing the line between treatment and resource recovery (and water reuse) or to attempt to get an opinion from the IRS prior to financing. The latter course would involve an expenditure of time and money, and it is questionable whether IRS would in fact commit itself firmly in advance.

The IRS has established a considerable capability for making technical judgments as to where treatment ceases and recovery begins. The risk that an unfavorable IRS finding may be made subsequent to financing would certainly influence businessmen to seek straight bank financing. For example, if the system design calls for recovery but the anticipated recovery can be proved to be minimal, tax-exempt financing might be allowed. But a subsequent industrial process change might be made which would greatly increase use of recoverable metals; now the process becomes a "profit-enhancing" activity for which tax-exempt funding is not allowed. In fact, depending on the amount of investment needed, there may not be much difference between bank and bond financing from the businessman's viewpoint. Against the cheaper bond money must be balanced the risks, added costs, and time required. In Massachusetts the company must prepare a plan of the waste treatment project which is submitted to the Industrial Development Financing Authority of the city or town. The IDFA then recommends approval to the municipal government; the selectmen or mayor approve(s) the plan, and application is made to the State Finance Board for a certificate of convenience and necessity. The prospective issue has been studied, prior to this point, by bond counsel and a trustee or bank having trust authority. State approval takes from eight to ten weeks from the time of requesting the certificate. There are expenses attached to the procedure, and in addition there is the risk that if there is a profit engendered by the process or equipment the IRS may disallow the tax-exempt status of the bonds. Because of the cost aspect, there is a feeling that below a certain minimum amount (perhaps $500,000) it is not worth financing by bond.

Leasing of pollution control equipment is a viable alternative; ownership and depreciation entitlement of the equipment and/or facilities remain in outside hands and the company pays a rental fee. One hundred percent financing is thus available and generally the term is longer than that available from banks. Ten years is not unusual. Companies are able to acquire significant leverage in this way. The cost is higher for this type of financing than for other methods, but since the company can avoid showing long-term debts on its balance sheet and may not be affecting its normal short-term lines of bank credit, leasing may be a preferred alternative. Leasing should be compared with the depreciation and tax credits that the company would have had if it had purchased the equipment. In the end many factors influence the decision as to financing; only in cases where the amount required is very substantial will bond financing become clearly the more attractive option.

Taxes--Group ownership would not give participants an opportunity to write off losses against profits earned elsewhere, unless one member owns 80 percent or more of the company. Only that owner could consolidate the losses of the service company with the parent company's books.

OPERATION OF A GROUP TREATMENT FACILITY: SOME ISSUES

Recovery of Materials

It is important to the three companies that an adequate system of accounting for salvable metals be established so that each company will be credited with the proper amount. At present the metal concerned is silver. In the future other metals, particularly copper and possible nickel, may be involved. Since the price of silver fluctuates over time, the accounting system should record the amounts credited to each company by date. A question arises as to whether each participating company should deal directly with the refiner, or whether the joint treatment facility should do so on their behalf. Companies could prefer to retain direct control over their silver and therefore could choose to have only treatment of wastes performed by the joint facility.

Transportation of Wastes

Wastes have to be transported to the group treatment facility and the only cost-effective way of accomplishing this is by trucking. As with other equipment, the truck or trucks could be owned by the group treatment facility, with costs proportioned among users; alternatively, each user could provide its own truck. The decision will depend on the amount of use required and the total cost picture. Unlike other treatment equipment, a truck would have to be separately licensed and insured, and its operation presents risks of lawsuits for damages by anyone injured in an accident. A special permit for transporting hazardous wastes will have to be obtained.

Charging for Waste Treatment

The total treatment costs for any given time period depend on the volume and concentration of wastes; these in turn depend on manufacturing volumes and processes which constantly vary. While a rough estimate may be arrived at for each participating company (especially after some operating history has built up), a true apportionment of costs among participating firms will require an adjustment every so often, based on actual volumes. This adjustment could be on a quarterly or yearly basis. The initial financing of operating costs will require advance payments by users; these will have to be estimated.

Group Laboratory Facilities

Analysis of each batch of wastewater will have to occur before it is commingled with other companies' wastes to ensure proper crediting of silver, that no materials are present which will adversely affect the operation of the treatment system, and that concentrations are within design limits for the system. These analyses could be done prior to delivery of wastes from each company. A more cost-effective solution might be achieved by having a central, shared laboratory. Such a laboratory might be established only to serve the waste treatment function; or the work of an existing laboratory might be expanded to include the group waste treatment work, with the addition of personnel and equipment. Adding laboratory capabilities to the group treatment system provides significant savings over the alternative of having each participant performing its own analyses.

SUMMARY

Management is not always aware of the environmental aspects of a company. It may not recognize that the material discharged to the sewer or the chemical-filled 55-gallon drums brought to the local landfill are potentially toxic or hazardous. Similarly, management may not be aware of the firm's responsibility for actions or problems resulting from the disposition of these waste materials. Then a manager might erroneously consider waste treatment as peripheral to the firm's business; and when in-plant processes are upgraded, they may not be optimized for the total plant, including waste generation.

This chapter has stressed that waste treatment is part of the business plan and indeed could be a separate business. Just as there are risks to be assumed in normal business endeavors there are risks to be accounted for in waste treatment. Therefore, this plan for group treatment has included methods for minimizing these risks: the companies are not connected by a continuous system where incidential dumps could hurt the system--batch wastes can be individually analyzed to prevent this. Also a structure of joint responsibility has been discussed to provide for apportionment of risk and perhaps to accommodate the addition or deletion of firms as desired.

In this way, costs can be lowered for waste treatment, additional material can be recovered, and an environmentally acceptable system can be provided.

THE TAUNTON SILVER COMPANIES

The three Taunton silver companies which are the subject of this report throughly evaluated the alternatives presented in this report as part of their overall consideration of joint waste treatment. Their considerations included most of the issues mentioned above. They have elected to not enter into a joint venture at this time. There was a general feeling that the problems of joint ownership, financing and the competitive positions could be worked out. However, other factors lead to the decision that each should go its own way. F.B. Rogers had completed planning for its batch waste treatment facilities as it was on an earlier compliance schedule than the other two companies. Poole Silver elected to merge its metal finishing operations with another firm within the Towle Manufacturing Co., and in doing so, eliminated the need to install treatment facilities. Reed & Barton decided to provide its own batch treatment facilities using design concepts that would permit it to expand capacity should it elect to do batch treatment on a contract basis some time in the future.

CHAPTER VII

SUMMARY

The best way to review and evaluate a project of this nature is to consider the steps through which it has progressed. In this way, the total project can be understood in terms of its key variables, thus permitting duplication as desired.

Step One

Identification of Problem

The concept began at an industrial meeting under the auspices of the regional Section 208 program at the local Chamber of Commerce. That discussion focused on potential aspects of the pretreatment program that the city soon would be required to implement along with the upgrading of its municipal sewage treatment facility. There was a great deal of uncertainty as to what the specific requirements for the participating industries would be, but there was a general sense of a need for strict metallic limits in order to protect the municipal facility and meet its discharge permit.

Step Two

Consideration of Cost-Effective Solutions

At the conclusion of the meeting, one of the industrialists in particular, who understood the situation, explained that he and the others would need help. Since there were a number of companies in the city with similar product lines and probably similar waste streams, some means of group treatment seemed an appropriate approach to the problem. Subsequent discussions with several of the plant engineers again showed the concern of meeting pretreatment regulations and an interest in a group project. From this start, it was necessary to go to the management levels of the companies next: first, to explain the nature of the coming regulations and, second, to describe a potential group solution.

Step Three

Development of Approach

It was deemed interesting to three companies in particular, which decided to explore the possibility of EPA R&D funding, as there was no precedent for establishment of such a group pretreatment program. Upon selection of an engineering consultant and an institutional subcontractor to accomplish the work, an application was submitted to EPA.

At that time, the three companies signed a "Letter of Intent" indicating their agreement to the overall project and to the designation of one company as "company of record" on the grant application.

The issues of timing and particularly of enforcement schedules became a concern early in the project. July 1977 deadlines were approaching and one nearby company decided not to participate during the initial discussions, believing his permit schedule would not allow a delay. One of the primary three companies was in a similar situation, splitting its effluent between an NPDES permit to the river and the municipal facility. This company elected to stay in the project, recognizing however that most of its waste streams were committed to the scheduled installation and hence not available to group treatment.

Similarly, one of the interested secondary companies in a nearby community was also on a permit schedule and hence not eligible for full consideration. Just before the actual grant acceptance, the other secondary company in a neighboring community was placed on a pretreatment schedule, disallowing its consideration except in a marginal sense. However, the primary three companies continued their participation in the feasibility study as described and divided their costs on a three-way basis.

Step Four

Designation of Common Elements

At the start of the study each of these three plants was analyzed for common characteristics of all batch discharges, including sludges, and of rinse water systems. A chart was drawn up showing alkali cleaners, acids with various metals, cyanides, salvable and inert sludges, hexavalent chromium, and solids. In this way, the three companies' waste materials were compared to determine candidates for group treatment. From this list ten batch wastes suitable for common treatment and disposal were described.

Acids

1. Those high in silver-strips, etchants
2. Those high in copper sulfuric pickles, bright dips
3. Those high in nickel-strips, dragout recovery
4. Those that are relatively low in metal content
5. Those containing hexavalent chromium

Cyanides

6. Those high in silver--filter wash water, floor spill, dragout recovery, strike baths, strips
7. Those high in copper--same sources as for silver
8. Those low in metal content

Sludges

9. Those resulting from waste treatment which have solids content below 10 percent solids
10. Those that are untreated--solids removed from the bottom of a process tank, for example

Step Five

Designation of Discharge Points and Disposal/Recovery System

Next, the issue of size and location of the companies was considered. Which ones were limited by space and perhaps personnel, and which had access to receiving waters as well as to the municipal sewer? Was there a more centralized location at one plant rather than at another? Discharge to the municipal sewer would limit the project to companies within the city, whereas discharge to a river would limit the size to reasonable transportation distances within the state.

Step Six

Evaluation of Regulatory Procedures

Discharges both to receiving waters and to the municipal sewer would require permits, monitoring and reporting. Similarly, discharge to a hazardous waste landfill would necessitate a permit, monitoring and reporting. There were interactions to be considered and discussed with the EPA regional office, the State Water Pollution Control Agency, and the city department of sewers. The city's sewer ordinance, with its specific metallic limits, was approved by the EPA and the state but still was under review by the local City Council during the progress of the study. It was made available, however, to the three companies and their consultants. The issue of antidegradation on one segment of the river became a concern. All of these regulations and requirements were evaluated as part of the study.

Step Seven

Economic Analysis of Alternatives

The cost-estimating procedure began with individual plant alternatives considering water conservation techniques and various known technologies to meet the different discharge requirements of the river and the municipal sewer. Group alternatives were then developed on the basis of the individual alternatives in order to compare costs. Material recovery proved to be one of the most important elements of the group treatment program.

Step Eight

Evaluation of Institutional/ Financial Elements

Similarly, institutional arrangements were analyzed: who would own the treatment plant(s), how it would be financed, and how it would be operated. The State Department of Commerce and Development was interested in pollution control bonding but was unaware of IRS consideration of material recovery as part of the project. Similarly, local banks were interested in various financial alternatives. There were some new questions to ask, and there were some new decisions to make, but it was institutionally feasible.

Step Nine

Consideration of Potential Project Expansion

The number of companies likely to participate was evaluated in a preliminary manner. With the assistance of the local Chamber of Commerce, a brief questionnaire was distributed to companies having potential waste streams matching the ten batch categories. Interest was expressed on the part of several, but without the city's proclamation of the sewer ordinance with its metallic limits, companies were hesitant to release specific information. Many were not even aware of the upcoming sewer ordinance and their potential pollutants to the municipal sewer.

Step Ten

Final Analysis of Alternatives and Decisions

At the completion of the study, the three companies had received much data--technical, regulatory, financial and institutional. They must evaluate this information in order to make required decisions. With the release of the municipal sewer ordinance including the compliance schedule, a citywide focus on this project has developed.

APPENDIX A

REED & BARTON SILVERSMITHS

GENERAL DESCRIPTION

Established in 1824, Reed & Barton is one of this country's oldest and largest major silverware manufacturers. With the exception of the 8-year-old 117,000 square foot Holloware plant, most of the buildings were erected in the late 1800s. All of Reed & Barton's manufacturing facilities are located in the Taunton industrial complex, which is split by a small river, making the control of the company's effluents all the more difficult.

The company started making the first American-made Britannia metal, and from there the company diversified into silver electroplating and sterling silver. Reed & Barton currently employs over 700 people in both manufacturing and administrative capacities.

Product Line

Reed & Barton today manufactures one of the most diverse product lines in the silverware industry. In flatware, Reed & Barton is the only silverware company which offers all five flatware products: sterling silver, Sterling II, silverplate, stainless and pewter. The company's holloware products include sterling silver, silverplate, stainless steel and pewter.

The Reed & Barton organization also includes two wholly owned subsidiaries --Eureka Manufacturing, a large manufacturer of wooden silverware and jewelry chests, and Sheffield Silver, manufacturer of silverplate and pewter holloware --both located in nearby Norton, Massachusetts.

INDUSTRIAL WATER USE

In the production of both holloware and flatware, the most predominant and repetitive metal finishing process is that of alkaline cleaning for removal of surface soils. Parts are cleaned after stamping, prior to annealing, after soldering for flux removal, after grinding and polishing, and prior to electroplating. Cleaning operations are also associated with color glaze application, chasing, repair steps and final finishing.

Acid processing is used to a much lesser extent. Most acid processing uses the common mineral acids, hydrochloric, sulfuric and nitric for removal of scales resulting from annealing and oxides resulting from brazing and soldering operations. Weaker acids are used prior to electroplating, with fluoboric acid required by the tin-lead alloys and for repair steps, and in the application of oxide films.

Cyanide processing is predominant for the electrodeposition of copper and silver, with a minor amount of cyanide gold salts in use. Cyanide is also associated with a few of the cleaning operations in repair and final finishing steps and with a few unique steps prior to electrodeposition.

Process water is also used in mechanical deburring steps that include conventional vibratory and horizontal tumbling techniques in the operation of a laundry and in the boiler house.

Other plating steps that are used occasionally are acid copper plating, nickel plating and black nickel deposition. Stripping of plating fixtures and some plated parts is accomplished in both cyanide and acid media.

Cooling water is used in the operation of vapor degreasers, hydraulic presses, vacuum pumps, air compressors, annealing furnaces, gas generators, casting furnaces, air conditioning, ultrasonic generators and some rectifiers. Contact cooling water results from knife blade grinding.

The above operations that require industrial water use are performed in some 30 different departments that are scattered throughout 12 buildings, some of which have two and three floors for various wet processing. Figure 1 layout of the total facility, shows the relative locations of operations using cooling and process water. It will be noted that there are six different locations for connections for process and cooling water to sanitary sewers and two discharge points for cooling water to the river. The complexity of joining common process streams for treatment purposes is compounded by the Mill River which divides the facility roughly in half.

Table 4 shows the various sources of flowing process water discharged to each of the six manholes. Not shown are single discharge points such as the laundry, which discharges into Manhole 1, or the river discharge for cooling water. Figures 2 and 3 are abbreviated flow diagrams showing the various types of water discharging to each outlet. Not shown are those individual connections to the sanitary sewer which contain only sanitary wastewater.

Quantity Initially Observed

Before this project some efforts had been directed toward water conservation. Additional effort is presently underway to further reduce the amount of industrial water used. At the time of the initial survey to establish a data base for this study, it was revealed that the following amount of water was being discharged:

Cooling water - 321,000 l/day (85,000 GPD) at a rate of 550-750 l/min (147-200 GPM)

Process rinse water - 520,000 l/day (137,000 GPD) at a rate of 1510 l/min (400 GPM)

A breakdown by discharge point for the quantity and rate of flow is provided in Table A-2.

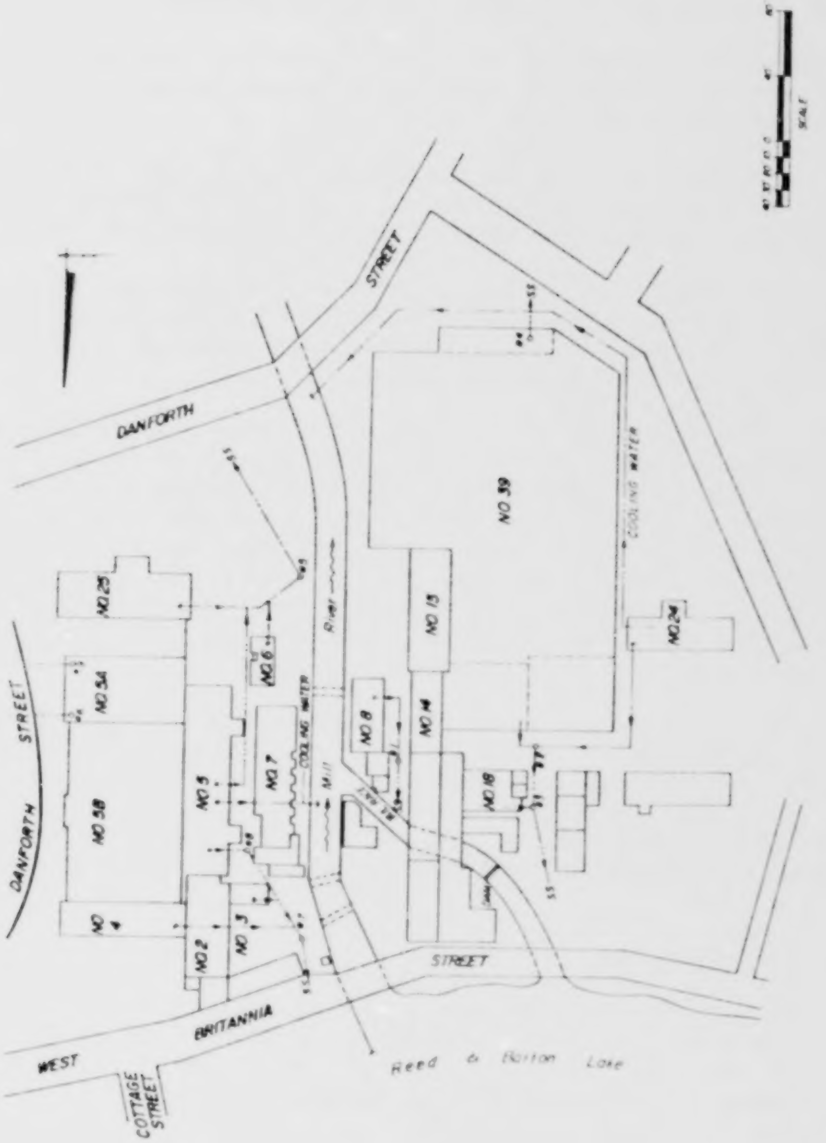

DANFORTH STREET
DANFORTH STREET
WEST BRITANNIA STREET
COTTAGE STREET
Reed & Barton Lake
NO 25
NO 54
NO 58
NO 4
NO 2
NO 3
NO 5
NO 6
NO 7
NO 8
NO 13
NO 14
NO 18
NO 24
NO 39
COOLING WATER
COOLING WATER
River
Mill
SS
SCALE

FIGURE 2. REED & BARTON SILVERSMITHS - FACILITY LAYOUT

TABLE 4. DRAIN SYSTEM

Manufacturing Process:	Rate		Daily Discharge	
Type of Discharge	1/min	GPM	Liters	Gallons
BUILDINGS 15, 20C, 39 TO MANHOLE 2				
Holloware Plating:				
Acid/alkali cleaning	153	(40.5)	82,800	(21,900)
Cyanide - plating	97	(25.5)	46,300	(12,200)
Cyanide - nonplating	5.7	(1.5)	3,070	(810)
Noncyanide plating	5.7	(1.5)	3,070	(810)
Cooling water	9	(2.5)	5,680	(1,500)
Color Glaze:				
Cleaning	45	(12)	4,770	(1,260)
Holloware Finishing:				
Alkali cleaning	51	(13.5)	20,900	(5,520)
Cyanide - nonplating	11	(3)	2,270	(600)
Gilding and Etching:				
Acid/alkali cleaning	45	(12)	8,860	(2,340)
Cyanide - plating	45	(12)	10,200	(2,700)
Cyanide - nonplating	91	(24)	15,400	(4,080)
Noncyanide plating	11	(3)	1,140	(300)
Acid etch	57	(15)	6,810	(1,800)
Solvent cleaning	34	(9)	4,770	(1,260)
Cooling water	57	(15)	31,000	(8,190)
Chasing:				
Cooling water	9	(2.5)	1,140	(300)
Repair:				
Acid/alkali cleaning	19	(5)	10,200	(2,700)
Cyanide - plating	11	(3)	8,450	(1,440)
Reclamation:				
Metal recovery water*	11	(3)	1,360	(360)
BUILDING 39 TO MANHOLE 4				
Holloware Stamping:				
Alkali spray washer	11	(3)	6,130	(1,620)
Acid cleaning	45	(12)	2,730	(720)
Cooling water	53	(14)	33,200	(9,760)
Holloware Making:				
Acid spray washer	23	(6)	9,080	(2,400)
Acid/alkali cleaning	19	(5)	10,900	(2,880)
Holloware Polishing:				
Alkali spray washer	11	(3)	5,450	(1,440)
Cooling water	125	(33)	60,000	(15,800)

* One day a month.

TABLE 4 (continued). DRAIN SYSTEM

Manufacturing Process: Type of Discharge	Rate 1/min	Rate GPM	Daily Discharge Liters	Daily Discharge Gallons
BUILDINGS 5, 6, 25 TO MANHOLE 5				
Sterling Holloware Making:				
Acid/alkali cleaning	28	(7.5)	13,600	(3,600)
Etch	19	(5)	9,080	(2,400)
Cooling water	19	(5)	9,080	(2,400)
Knife Blade Forging:				
Cooling water	38	(10)	22,700	(6,000)
Knife Blade Grinding:				
Alkali cleaning	23	(6)	10,900	(2,880)
Contact cooling	34	(9)	13,600	(3,600)
Cutlery Making:				
Cooling water	2	(0.6)	1,640	(432)
Flatware Buffing:				
Acid oxidize	23	(6)	10,900	(2,880)
Flatware Finishing:				
Dichromate oxidize	28	(7.5)	5,110	(1,350)
Reclamation:				
Metal recovery water	45	(12)	5,450	(1,440)
Cooling water*	9	(2.5)	5,680	(1,500)
BUILDINGS 5A, 5B TO MANHOLE 6				
Flatware Stamping:				
Alkali spray washer	7.6	(2)	3,630	(960)
Acid/alkali cleaning	57	(15)	27,300	(7,200)
Cooling water	4.5	(1.2)	2,720	(720)
Flatware Polishing:				
Cleaning	70	(18.5)	33,600	(8,880)
Acid oxidize	9.5	(2.5)	4,540	(1,200)
Flatware Plating:				
Acid/alkali cleaning	79	(21)	21,800	(5,760)
Cyanide - plating	68	(18)	15,300	(4,050)
Cyanide - nonplating	11	(3)	1,360	(360)
Noncyanide plating	23	(6)	6,810	(1,800)
Marking/Scratch Brush:				
Cyanide - nonplating	39	(10.5)	10,300	(2,730)

* One day a week.

TABLE 4 (continued). DRAIN SYSTEM

Manufacturing Process: Type of Discharge	Rate l/min	 GPM	Daily Discharge Liters	 Gallons
BUILDING 5 TO MANHOLE 8				
Cutlery Making:				
Acid cleaning	17	(4.5)	8,180	(2,160)
Cooling water	30	(8)	10,900	(2,880)
Sterling Holloware Buff:				
Cyanide - nonplating	34	(9)	16,400	(4,320)
BUILDING 5A TO MANHOLE 9				
Flatware Buffing:				
Alkali spray washer	30	(8)	14,500	(3,840)
Alkali cleaning	23	(6)	10,900	(2,880)
Cyanide - nonplating	21	(5.5)	9,990	(2,640)

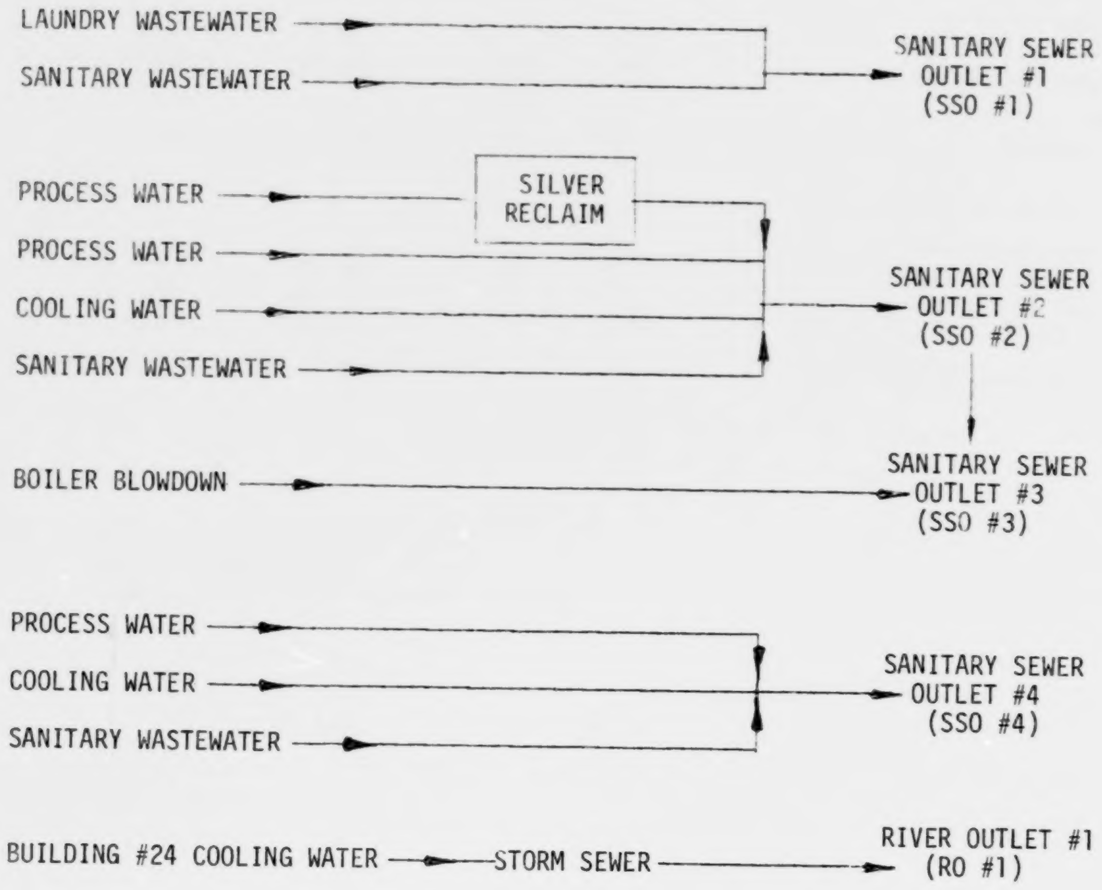

LAUNDRY WASTEWATER
SANITARY WASTEWATER
SANITARY SEWER OUTLET #1 (SSO #1)
PROCESS WATER
SILVER RECLAIM
PROCESS WATER
COOLING WATER
SANITARY WASTEWATER
SANITARY SEWER OUTLET #2 (SSO #2)
BOILER BLOWDOWN
SANITARY SEWER OUTLET #3 (SSO #3)
PROCESS WATER
COOLING WATER
SANITARY WASTEWATER
SANITARY SEWER OUTLET #4 (SSO #4)
BUILDING #24 COOLING WATER
STORM SEWER
RIVER OUTLET #1 (RO #1)

FIGURE 3. WASTEWATER DISCHARGE POINTS, WEST SIDE OF RIVER

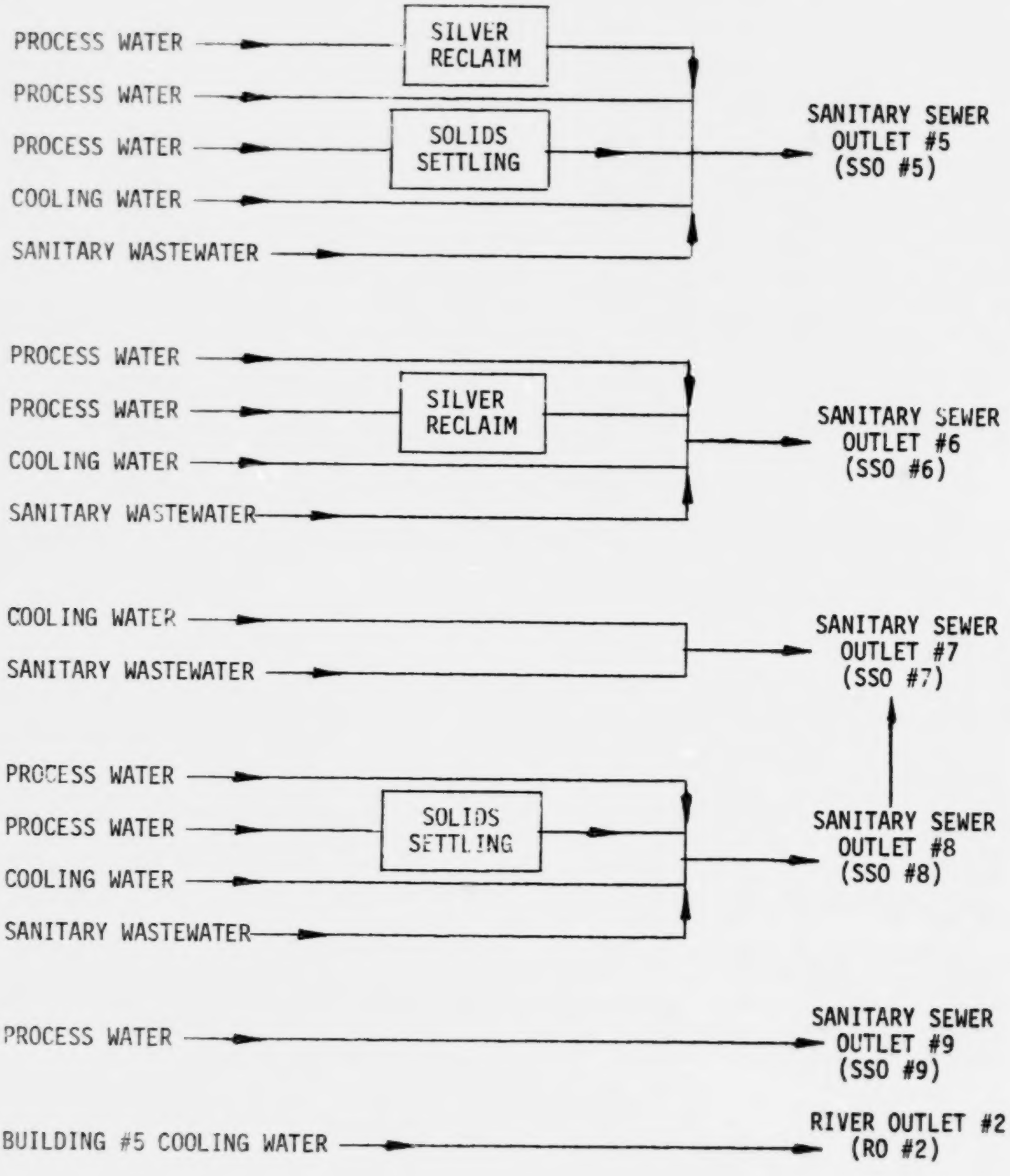

PROCESS WATER
SILVER RECLAIM
PROCESS WATER
PROCESS WATER
SOLIDS SETTLING
COOLING WATER
SANITARY WASTEWATER
SANITARY SEWER OUTLET #5 (SSO #5)
PROCESS WATER
PROCESS WATER
SILVER RECLAIM
COOLING WATER
SANITARY WASTEWATER
SANITARY SEWER OUTLET #6 (SSO #6)
COOLING WATER
SANITARY WASTEWATER
SANITARY SEWER OUTLET #7 (SSO #7)
PROCESS WATER
PROCESS WATER
SOLIDS SETTLING
COOLING WATER
SANITARY WASTEWATER
SANITARY SEWER OUTLET #8 (SSO #8)
PROCESS WATER
SANITARY SEWER OUTLET #9 (SSO #9)
BUILDING #5 COOLING WATER
RIVER OUTLET #2 (RO #2)

FIGURE 4. WASTEWATER DISCHARGE POINTS, EAST SIDE OF RIVER

TABLE 5. SUMMARY OF INDUSTRIAL WATER FLOW BY MANHOLE

Manhole	Rate		Daily Discharge	
	l/min	GPM	Liters	Gallons
Rinse Water:				
2	687	(182)	229,000	(60,500)
4	110	(29)	34,300	(9,060)
5	200	(53)	68,800	(18,200)
6	365	(96)	124,500	(32,900)
8	51	(13.5)	24,600	(6,480)
9	74	(19.5)	35,400	(9,350)
Cooling Water:				
2	75	(20)	37,800	(9,990)
4	178	(47)	93,200	(24,600)
5	68	(18)	39,100	(10,300)
6	4.5	(1.2)	2,720	(720)
7	34	(9)	49,100	(13,000)
8	30	(8)	10,900	(2,880)

Quality of Discharge

During the year preceding this study, various samples were taken from seven sample points (observation manholes). The results of the analyses of six of these samples are shown in Table 6. The seventh sample showed the contamination from laundry operations at Manhole 1. It is believed that the analysis reflects the quality of city water in use rather than contamination by processing. The pH was in the range of 2.5 to 5.9 and copper in the range of 0.9 to 2.0. It is believed that the quality is typical of flowing rinse water that has been diluted with nonprocess water. All but one discharge point (Manhole 9) was intermixed with sanitary wastewater and cooling water.

Since these samples were taken, some water conservation steps have been taken and several chemical process changes have been implemented. For the purposes of this study, additional average composite samples were taken. The results are shown in Tables 7 and 8. They are believed to be representative of present conditions and serve as a data base for this project.

TABLE 6. RESULTS OF ANALYSES OF WASTEWATER*

Item	Concentration, mg/l	
	Range	Average
MANHOLE 3†		
Cyanide	1.7 - 3.5	2.3
Copper	2.6 - 3.0	2.8
Silver	1.1 - 3.6	2.0
Zinc	0.2 - 0.4	0.3
Lead	<0.05 - 0.11	<0.07
Iron	2.0 - 3.8	3.0
Nickel	0.03 - 0.23	0.13
Chromium	<0.01 - 0.02	0.01
Solids, suspended	N/A	26.0
Solids, total	164 - 614	389.00
pH, units, mean	3.0 - 11.6	8
MANHOLE 4		
Cyanide	N/A	<0.1
Copper	1.1 - 5.9	3.0
Silver	N/A	<0.1
Zinc	0.2 - 2.6	1.2
Lead	0.12 - 0.50	0.26
Iron	1.4 - 2.5	2.0
Nickel	0.02 - 0.10	0.06
Chromium	<0.01 - 0.02	0.01
Solids, suspended	N/A	10
Solids, total	44 - 138	93
pH, units, mean	3.1 - 7.3	5
MANHOLE 5		
Cyanide	N/A	<0.1
Copper	0.13 - 0.71	0.38
Silver	<0.01 - 0.57	0.24
Zinc	0.25 - 0.44	0.32
Lead	<0.05 - 0.10	<0.08
Iron	22.5 - 34.0	27.2
Nickel	0.08 - 0.15	0.12
Chromium	2.6 - 4.8	3.4
Solids, suspended	N/A	26
Solids, total	162 - 200	181
pH, units, mean	2.8 - 6.4	5

*Source: City of Taunton Sewer Department, May 6, 1976 through October 19, 1976.

†Manhole 3 receives discharge from Manhole 2 and boiler blowdown.

TABLE 6 (continued). RESULTS OF ANALYSES OF WASTEWATER

Item	Concentration, mg/l	
	Range	Average
MANHOLE 6		
Cyanide	<0.1 - 1.9	0.7
Copper	1.45 - 4.56	2.7
Silver	0.22 - 3.6	1.4
Zinc	0.27 - 1.17	0.7
Lead	<0.05 - 0.13	0.09
Iron	1.1 - 1.8	1.4
Nickel	2.2 - 3.8	3.0
Chromium	1.3 - 7.0	3.5
Solids, suspended	N/A	112
Solids, total	162 - 792	421
pH, units, mean	6.3 - 11.3	8
MANHOLE 8		
Cyanide	N/A	<0.1
Copper	1.2 - 1.4	1.7
Silver	0.3 - 2.8	1.1
Zinc	0.4 - 0.7	0.5
Lead	0.13 - 0.32	0.20
Iron	1.0 - 1.9	1.3
Nickel	0.13 - 0.20	0.18
Chromium	<0.01 - 0.04	<0.03
Solids, suspended	-	-
Solids, total	112 - 198	155
pH, units, mean	3.5 - 3.8	3.7
MANHOLE 9		
Cyanide	N/A	<0.1
Copper	0.43 - 0.66	0.52
Silver	0.04 - 0.08	0.06
Zinc	0.05 - 0.16	0.10
Lead	<0.05 - 0.07	<0.06
Nickel	N/A	<0.05
Chromium	N/A	<0.01
Solids, suspended	-	-
Solids, total	388 - 406	397
pH, units	11.2 - 11.3	11.2

TABLE 7. ANALYSIS OF WASTEWATER - WEST SIDE OF RIVER*

Item	Concentration, mg/l					
	SSO #1		SSO #3		SSO #4	
Cyanide, total	0.0045		1.15		0.0045	
Cyanide, amenable	0.0045		1.05		0.0045	
Silver	0.45	(0.02)†	0.54	(0.44)	0.04	(0.02)
Copper	2.01	(1.55)	4.92	(4.68)	1.26	(1.17)
Zinc	1.02	(0.95)	0.65	(0.20)	0.29	(0.27)
Tin	<0.1		<0.1		<0.1	
Lead	0.38	(0.32)	0.12	(<0.01)	0.07	(<0.01)
Nickel	0.06	(0.02)	0.30	(0.21)	0.07	(<0.01)
Iron	2.88	(2.17)	11.6	(0.03)	15.5	(0.24)
Chromium‡	0.02	(<0.01)	0.02	(<0.01)	0.03	(<0.01)
Solids, suspended	46.0		27.9		35.3	
Solids, total	397.0		152.0		104.0	
pH, units	3.41		7.32		3.35	

*Source: New England Chemical Works, Whittenton Industrial Center, Taunton, Massachusetts, June 9, 1977.

†Values given in parentheses are for dissolved metals.

‡No hexavalent chromium.

TABLE 8. ANALYSIS OF WASTEWATER - EAST SIDE OF RIVER*

Item	Concentration, mg/l							
	SSO #5		SSO #6		SSO #8		SSO #9	
Cyanide, total	0.0045		0.117		0.048		0.012	
Cyanide, amenable	0.0045		0.066		0.040		0.006	
Silver	0.04	(0.02)†	0.07	(0.00)	0.035	(0.035)	0.13	(0.04)
Copper	0.20	(0.02)	0.80	(0.57)	0.64	(0.33)	0.62	(0.48)
Zinc	0.17	(0.05)	0.11	(0.08)	1.30	(0.77)	0.34	(0.03)
Tin	<0.1		<0.1		<0.1		<0.1	
Lead	0.05	(<0.01)	0.07	(<0.01)	0.035	(<0.035)	<0.01	
Nickel	0.10	(<0.01	2.83	(2.65)	0.13	(0.08)	0.15	(0.10)
Iron	32.4	(0.02)	2.88	(0.16)	0.92	(0.30)	2.59	(0.21)
Chromium‡	3.94	(<0.01)	0.52	(<0.01)	0.02	(0.02)	0.09	(<0.01)
Solids, suspended	50.5		35.5		6.5		33.0	
Solids, total	165.0		133.0		117.0		419.0	
pH, units	6.7		6.29		7.58		11.27	

*Source: New England Chemical Works, Whittenton Industrial Center, Taunton, Massachusetts, June 9, 1977.

†Values given in parentheses are for dissolved metals.

‡No hexavalent chromium.

Production practices during both sample periods held batch dumps of spent process solutions to a minimum. Table 9 shows the quantity of batch discharges by discharge point. Table 10 shows a summary of the batch discharge by type for the entire plant. Obviously, the concentration of the various contaminants would be higher during these dump periods.

TABLE 9. BATCH DISCHARGES BY MANHOLE

Manhole	Volume, liters/year (gallons/year)					
	Alkalies		Acids		Cyanides	
1	123,000	(32,500)	0		0	
2	886,000	(234,000)	109,000	(28,900)	170,500	(45,000)
3	497,000	(131,400)	0		0	
4	79,100	(20,900)	38,100	(10,100)	0	
5	168,000	(44,500)	3,650	(964)	485	(128)
6	98,000	(25,900)	720	(190)	2,760	(730)
7	190	(50)	0		0	
8	13,250	(3,500)	38	(10)	0	
9	147,000	(38,800)	500	(132)	0	

TABLE 10. SUMMARY OF BATCH DISCHARGES BY TYPE

Type	Subtype	Volume liters/year	(gallons/year)
Alkali	Spray Wash Cleaners	270,000	(71,300)
	Other Alkali Cleaners	526,000	(139,000)
	Exhaust Scrub Water	473,000	(125,000)
	Laundry	615,000	(162,500)
	Boiler Blowdown	496,000	(131,000)
	Total Alkali	2,380,000	(628,800)
Acid	Low Silver Content	103,000	(27,300)
	High Silver Content	4,300	(1,140)
	Total Acid	107,300	(28,440)
Cyanide	Low Silver Content	31,700	(8,390)
	High Silver Content	155,200	(41,000)
	Total Cyanide	186,900	(49,400)
Solvents	(not to sewer)	3,860	(1,020)

Anticipated Segregation and Conservation

Sanitary wastewater discharge will be segregated from industrial use wastewater. Cooling water will be partially segregated from wet process wastewater. That cooling water which is not segregated is reused as process rinse water. Water conservation techniques will reduce the amount of cooling water discharged.

Counterflow rinsing will reduce the amount of wet process wastewater. Other conservation techniques will further reduce the amount of process water discharged. It is anticipated that all cooling water that is not reused as process water will be eliminated from direct discharge to the sanitary sewer. It is anticipated that a minimum of 25 percent reduction in wet process rinse water will result. A minimum of 500,000 1/day (135,000 GPD) reduction will be accomplished prior to the installation of pollution control facilities. Simplified flow diagrams of process water only, resulting from this segregation, is shown in Figures 5 and 6.

Anticipated Quality of Raw Waste Discharge

Due to the magnitude of the segregation of sanitary wastewater, cooling water and wet process wastewater, it is not possible to accomplish the segregation before the completion of this project. Due to the present intermix of these three types of wastewater, it is not possible to obtain representative samples of only wet process wastewater for analysis. Likewise, the impact of future water conservation efforts cannot be felt in time to be meaningful for qualification of the raw waste requiring treatment.

However, it is possible to calculate a theoretical discharge from the various analyses obtained for the data base. It can be considered that the theoretical discharge excludes the cooling water and that water conservation efforts will be implemented. Errors will exist in that it is not possible to do more than estimate the amount of water used for sanitary purposes which has a dilution effect. Likewise, it is not practical to include in the contaminant loading those contributions caused by the raw city water.

It is anticipated that all process wastewater may be brought to a single location for pretreatment. Weighting the results of analyses shown in Tables 7 & 8,with the daily discharge in the tables showing the amount draining through each manhole, and considering the water conservation anticipated, a value for each major contaminant has been predicted and is shown in Table 11. As an estimate this shows the general order of magnitude for discharge from the total plant for process wastewater. Not shown on this table is hexavalent chromium that appears from time to time when certain part-time operations are being used. The concentration anticipated when it is present is in the range of 1-3 mg/l. Other metals that may appear from time to time are mercury and tellurium.

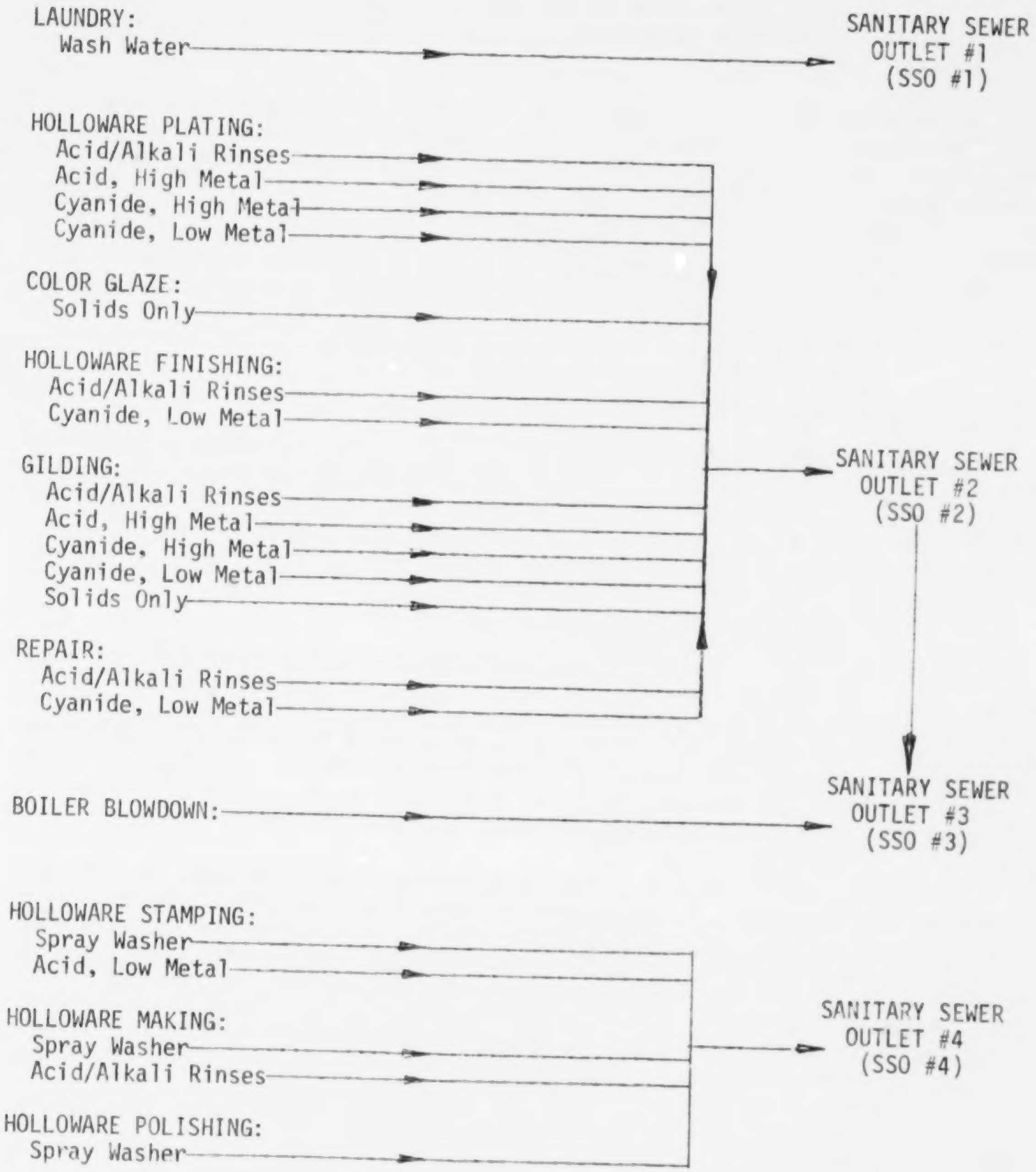

LAUNDRY:
Wash Water
SANITARY SEWER OUTLET #1 (SSO #1)
HOLLOWARE PLATING:
Acid/Alkali Rinses
Acid, High Metal
Cyanide, High Metal
Cyanide, Low Metal
COLOR GLAZE:
Solids Only
HOLLOWARE FINISHING:
Acid/Alkali Rinses
Cyanide, Low Metal
GILDING:
Acid/Alkali Rinses
Acid, High Metal
Cyanide, High Metal
Cyanide, Low Metal
Solids Only
REPAIR:
Acid/Alkali Rinses
Cyanide, Low Metal
SANITARY SEWER OUTLET #2 (SSO #2)
BOILER BLOWDOWN:
SANITARY SEWER OUTLET #3 (SSO #3)
HOLLOWARE STAMPING:
Spray Washer
Acid, Low Metal
HOLLOWARE MAKING:
Spray Washer
Acid/Alkali Rinses
HOLLOWARE POLISHING:
Spray Washer
SANITARY SEWER OUTLET #4 (SSO #4)

FIGURE 5. PROCESS RINSE WATER, WEST SIDE OF RIVER

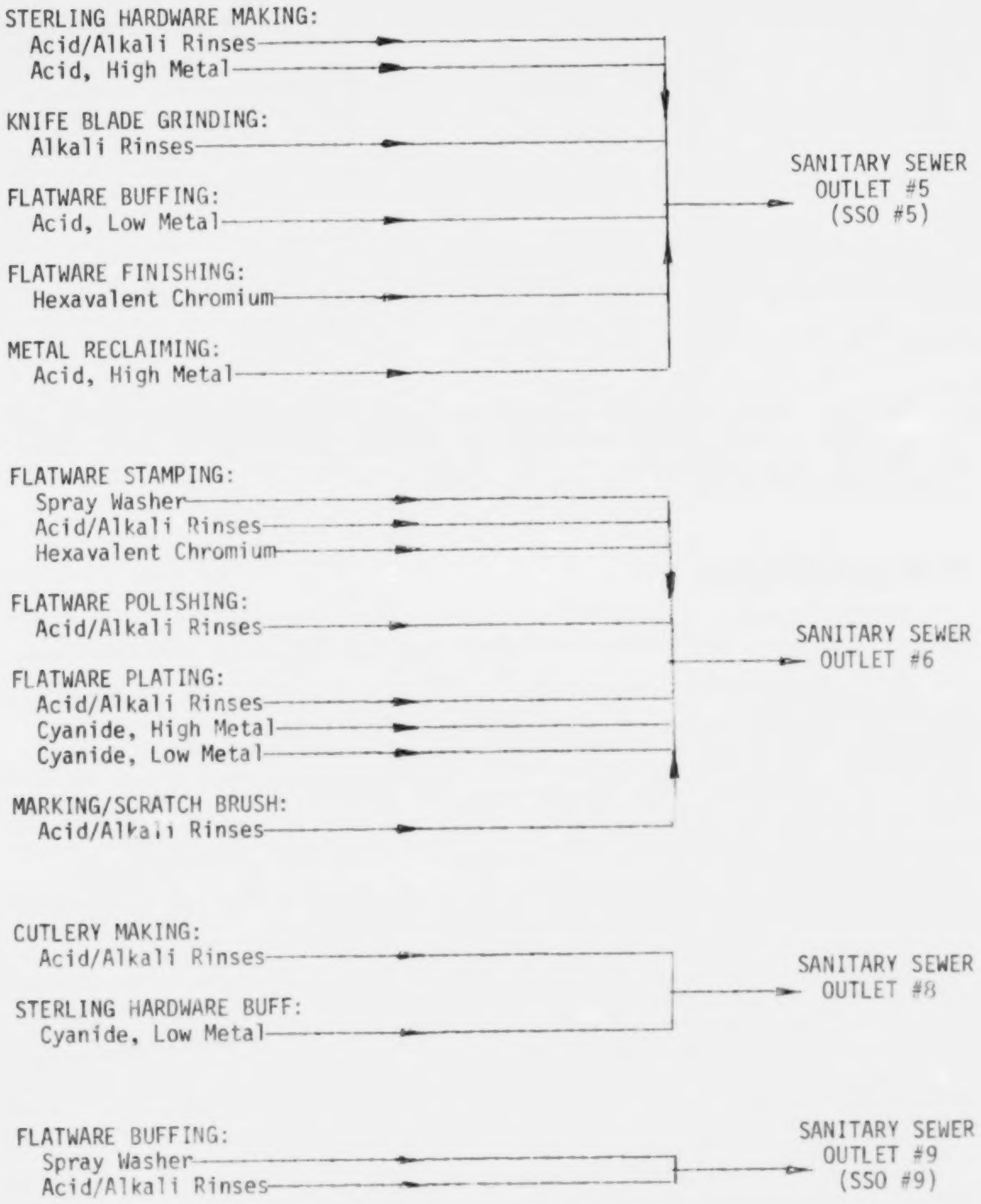

STERLING HARDWARE MAKING:
Acid/Alkali Rinses
Acid, High Metal
KNIFE BLADE GRINDING:
Alkali Rinses
FLATWARE BUFFING:
Acid, Low Metal
FLATWARE FINISHING:
Hexavalent Chromium
METAL RECLAIMING:
Acid, High Metal
SANITARY SEWER OUTLET #5 (SSO #5)
FLATWARE STAMPING:
Spray Washer
Acid/Alkali Rinses
Hexavalent Chromium
FLATWARE POLISHING:
Acid/Alkali Rinses
FLATWARE PLATING:
Acid/Alkali Rinses
Cyanide, High Metal
Cyanide, Low Metal
MARKING/SCRATCH BRUSH:
Acid/Alkali Rinses
SANITARY SEWER OUTLET #6
CUTLERY MAKING:
Acid/Alkali Rinses
STERLING HARDWARE BUFF:
Cyanide, Low Metal
SANITARY SEWER OUTLET #8
FLATWARE BUFFING:
Spray Washer
Acid/Alkali Rinses
SANITARY SEWER OUTLET #9 (SSO #9)

FIGURE 6. PROCESS RINSE WATER, EAST SIDE OF RIVER

TABLE 11. THEORETICAL COMBINED PROCESS WATER QUALITY

Item	Concentration, mg/l
Cyanide, total	0.74
Cyanide, amenable	0.62
Silver	0.37
Copper	3.7
Zinc	6.7
Lead	0.11
Nickel	1.07
Iron	20.0
Chromium	1.1

The low values shown for cyanide are considered unrealistic, as the existing drain systems permit formation of hydrogen cyanide (HCN) which would not show up in the analysis. A more likely concentration is 50-75 times the amount shown after the proposed drain isolation.

Unique Considerations

At Reed & Barton Silversmiths there are several unique situations that produce industrial wastewater that requires unique treatment considerations.

In Buildings 3 and 4 there are photographic rooms that use conventional development techniques. Virtually all the chemical processing results in wastewater that is amenable to biological treatment along with the sanitary wastewater. The exception is the spent "hypo" which can contain amounts of dissolved silver that, when dumped, would be objectionable. The spent "hypo" will be transferred in containers to the waste treatment facilities for salvage of silver. The volume involved amounts to 190 l/yr (50 gal/yr).

In Building 8 a small laundry is used on a daily basis. The volume of wash water discharged daily is 2,500 liters (650 gallons). The laundry wastewater, mixed with sanitary waste, discharges into Manhole 1. The quality of this discharge is affected more by the poor quality of the raw water used for washing than by contamination caused by shop soils. The major contamination is the soaps and detergents used in washing. These are amenable to biological treatment along with sanitary wastewater. As the raw water quality improves, the amount of heavy metals in this effluent will be reduced. It is believed that optimum treatment will result if this wastewater continues to be treated as sanitary waste.

Steam is used for process and space heating. A major portion of the condensate is returned to the boiler house. Where there is little or no chance of contamination by process solutions, the condensate is returned. Otherwise, it is used as rinse water and reduces the amount of raw water required for rinsing. Boiler blowdown amounts to 1400 l/day (360 GPD). This is normally high in suspended solids and slightly alkaline. This wastewater will be treated along with other inert suspended solids.

In virtually all locations accidental discharges are kept from the sewer systems by curbs and dikes isolated from process tank drains. Those few remaining locations where the potential for accidental loss of solutions remains high are receiving attention to correct this situation. At the same time, potential accidental acid losses are being isolated from cyanides under an OSHA compliance program.

BASIC DESIGN CONCEPTS

With the exclusion of cooling water and sanitary wastewater, more simplified flow diagrams can be produced for wet process water. Figures 5 and 6 include segregation into process wastewater streams having common characteristics and/or methods of treatment. Tables 7 and 8 show the results of the analysis of composite samples taken early in this project for each of the major process water discharge points. Table 9 is a calculated value for the discharge with cooling water excluded. However, those values should be considered minimum values since dilution with sanitary wastewater remains.

Segregation of process wastewater will include two major factors: concentrated batch wastewater will be separated from flowing rinse water and segregation by treatment required will be accomplished. The analysis results shown in the various tables are in keeping with flowing rinses when batch discharges are kept to a minimum. The concentration in isolated discharge streams having common characteristics can only be estimated, as significant alterations to drain systems are required in order to obtain accurate samples.

Rinses can be segregated into the following seven subcategories:

- spray washing machines
- acids high in metal (Ag, Cu and/or Zn)
- hexavalent chromium
- acid/alkali low in metal
- cyanides high in metal (Ag and Cu)
- cyanides low in metal
- suspended solids only

Batch discharges can be segregated into:

- alkali cleaners
- acids high in metal
- acids low in metal
- cyanides high in metal
- cyanides low in metal

Alkaline cleaners, together with the rinses from spray washing machines, represent a significant segment of wastewater resulting from metal finishing operations which is unique from other wastewater types. This type of waste is characterized as being alkaline, being relatively high in suspended solids and containing low levels of dissolved heavy metals. The wetting agents and detergents are amenable to biodegradation by sanitary treatment systems. These same surface-active agents can cause treatment problems for removal of heavy metals common to other process water. Consequently, the preferred treatment for the alkaline cleaners and the spray washing machine water is to lower the pH, remove suspended solids where they are excessive, and then recombine with other treated wastewater for common discharge. Batch cleaners resulting from dumping practices will be collected and metered into the spray washer wastewater on a controlled basis to preclude shock loading.

Acid and alkali rinses will require pH control to minimize heavy metal solubility, followed by removal of the metal hydroxide and/or oxide.

Rinses containing hexavalent chromium will require reduction of chromium to the trivalent state, after which they can be treated as other acid wastewater.

Acid rinses that are high in metal concentration will have the metals reduced in concentration prior to treatment with other acid wastewaters.

Cyanide-bearing rinse water will require oxidation for cyanide removal. In the absence of cyanide, the metals become insoluble. The resulting water following oxidation will be treated as other acid/alkali-bearing rinse waters for pH control and removal of heavy metals. Where the isolated cyanide stream is considered to be high in salvable metal, pretreatment for removal of metal to a lower level is preferred before combining with other low metal content, cyanide-bearing water for oxidation.

Those waste streams containing only inert suspended solids will have the majority of solids removed prior to discharge along with other treated or partially treated water. Segregating these inert solids as sludges that are known to be free of heavy metal hydroxides (or oxides) presents less of a problem for ultimate disposals of residual solids.

Considering the previous segregation methods, Reed & Barton will have the following types and quantities of flowing rinse water:

spray washer rinses	10,300 GPD @	22 GPM max.
hexavalent chromium rinses	1,700 GPD @	5 GPM max.
acid rinses high in metal	4,300 GPD @	18 GPM max.
acid/alkali rinses	57,900 GPD @	140 GPM max.
cyanide rinses high in metal	8,200 GPD @	34 GPM max.
cyanide rinses low in metal	11,600 GPD @	34 GPM max.
solids-only rinse water	3,000 GPD @	21 GPM max.

Following preliminary treatment of high salvable, metal content rinses, of hexavalent chromium and of cyanides, a combined waste system will result for final pH adjustment that, together with other acid/alkali rinses, will require further removal of suspended metal hydroxides and oxides. This combined stream will amount to 84,000 GPD at a maximum flow rate of 230 GPM.

Following this pretreatment for removal of heavy metals, the wastewater may intermix with other process wastewater (spray washer rinses and solids-only rinse water) to produce a total process wastewater flow of 98,000 GPD at a maximum rate of 275 GPM.

Acid batches high in silver content will be isolated from acids with low recovery values. Metal extraction by pH adjustment or other means will result in a low metal content acid. This will be mixed with other low metal content acids for neutralization and metal hydroxide/oxide precipitation. The resulting sludge will be held for salvage, disposal or further dewatering.

Batch wastes containing hexavalent chromium will be isolated for reduction to the trivalent state before being neutralized like other waste acids.

Cyanide batches are normally high in cyanide concentration and dissolved metal. If the metal has salvage value, the metal will be extracted prior to cyanide oxidation. After metal extraction these cyanide batches will be mixed with other cyanide batches that are low in salvable metal. Cyanide oxidation will result in precipitated metal hydroxides and/or oxides. The sludge resulting is held for salvage, disposal or further dewatering.

PRIMARY DESIGN

Waste treatment facilities for Reed & Barton Silversmiths consider present effluent limitations, potential limitations by local and federal agencies, state-of-the-art treatment technology and economics as evident in 1977. The objective of the primary design is to form a basis for the evaluation of cost alternatives. This design provides a complete treatment system for Reed & Barton and does not consider involvement of other industries. The primary design may, therefore, be used to compare the cost effectiveness of the joint participation alternative versus the separate treatment alternative.

Design Criteria

The volume of process water currently discharged is 137,000 GPD which flows at an average rate of 400 GPM. The wastewater contains cyanide, silver, copper, nickel, iron, chromium, and zinc. The pH varies from alkaline to acidic and exceeds the limits recommended for sewer or river discharge.

It is estimated that Reed & Barton can reduce process water consumption by 25 percent. Assuming that the same quantities of material are discharged, there would be an increase in the concentration of objectionable material. The quantity of rinse water would be approximately 100,000 GPD flowing at a maximum rate of 275 GPM.

A significant portion (20 percent) of the wastewater results from cleaning operations. This water is far more amenable to biological treatment for removal of wetting agents than the remaining waters. Aside from occasional occurrence where the pH is too high, the cleaning water exhibits little, if any, objectionable qualities for discharge to a sanitary sewer system. At the same time, the sanitary treatment facilities do provide for removal of the contaminants to the total environment that are present in the cleaning wastewater.

The primary design criteria considers the optimum discharge site for cleaning wastewater to be the sanitary sewer. Other process wastewaters requiring cyanide and metal removal could be treated and discharged to the river since the quality criteria for discharge to the sanitary sewer in Taunton are more severe than for discharge to the river. Economics indicate a river discharge for this process water.

The high volumes of process wastewater are concerned with flowing rinse water. The rinses are characterized as being relatively low in contaminant concentration. Lesser volumes are associated with the periodic dumping of spent process solutions. The dumps are characterized as being significantly high in contamination, even though low in volume. The design criteria considers segregation of rinses and batch dumps of spent process solutions.

Segregation by type and treatability results in the waste streams for: cyanide rinses, chromium rinses, acid/alkali rinses, rinses containing only inert solids, and cleaner rinses.

The physical locations of the various waste-generating processes present severe problems if all wastewater is brought to a common location for treatment. The plumbing expenses become excessive. For the more complex treatment systems, this expense of combining can be justified. However, for some of the waste streams it is advisable to have more than one discharge for the sanitary sewer, as little is to be gained in combining these wastes for treatment purposes. The prime location for combined treatment is in Building 8 located on the west side of the river. Consequently, the preceding segregations at rinse are further subdivided by which side of the river they originated from:

- cyanide rinses, east side - 18 GPM
- cyanide rinses, west side - 52 GPM
- chromium rinses, east side - 5 GPM
- solids-only rinses, east side - 3 GPM
- solids-only rinses, west side - 9 GPM
- acid/alkali rinses, east side - 70 GPM
- acid/alkali rinses, west side - 54 GPM
- cleaner rinses, east side - 30 GPM
- cleaner rinses, west side - 24 GPM

Batch discharges, requiring disposal techniques that are different from rinses, can be segregated into:

• alkaline cleaners	- 28,000 gallons/month
• acids, high in silver	- 150 gallons/month
• acids, high in copper	- 500 gallons/month
• chromates	- 750 gallons/month
• acids, low in metals	- 2,000 gallons/month
• cyanides, high in silver & copper	- 4,000 gallons/month
• cyanides, low in metals	- 750 gallons/month
• inert sludges	- 600 pounds/month

The quality criteria used as the design basis considers the proposed local ordinance for discharge to the sanitary sewer to be more restrictive than the anticipated Federal Guidelines for Pretreatment. Discharges to the sanitary sewer shall meet the requirements as shown in Appendix E, "City of Taunton Sewer Ordinance."

The quality criteria used as the design basis for discharge to the river considers the requirements of the regulatory agencies in Massachusetts and Region I of EPA. The requirements are shown in Appendix F, "Water Regulations." It is assumed for the purposes of this report that the antidegradation clause does not apply for this discharge.

Treatment Proposed

Schematic presentations of the proposed treatment systems are shown on Figure 7 for discharge to the river, on Figure 8 for batch treatment, and on Figure 9 for discharges to the sanitary sewer. A description of the various subsystems is provided:

Rinse Water, River Discharge--

Cyanide-bearing rinses are isolated from all noncyanide-bearing process waters. The collection system on the east side of the river includes means to deliver the wastewater to the west side of the river for treatment. At the centralized treatment site all cyanide-bearing rinses are initially combined in a buffer (or equalization) tank. A two-step chlorination process removes cyanides and cyanates. The resulting water contains copper hydroxide and silver oxide, both of which are present as suspended solids. Gravity settling of suspended solids is provided to reduce these solids to an acceptable level. Solids removal is enhanced by the addition of a polyelectrolyte. The sludges removed by settling are concentrated and collected for salvage values.

Hexavalent chromium-bearing rinses are isolated from all nonchromium-bearing process waters. All of this type of water is on the east side of the river. The collected wastewater receives pretreatment for reduction of the

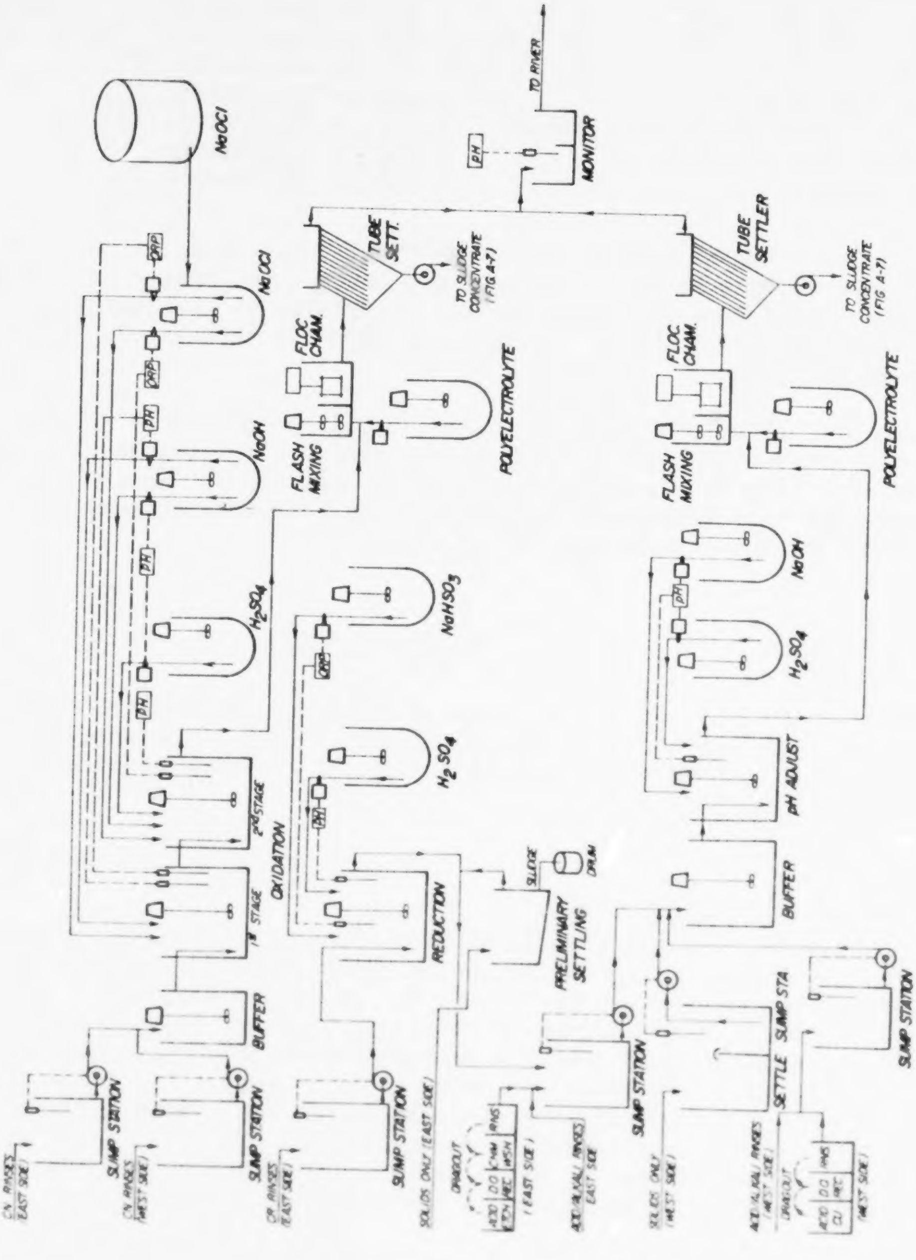

NaOCl
NaOCl
ORP
ORP
PH
NaOH
PH
H2SO4
PH
1st STAGE
2nd STAGE
OXIDATION
BUFFER
SUMP STATION
SUMP STATION
CN RINSES (EAST SIDE)
CN RINSES (WEST SIDE)
NaHSO3
ORP
H2SO4
PH
REDUCTION
SUMP STATION
CR RINSES (EAST SIDE)
SOLIDS ONLY (EAST SIDE)
FLASH MIXING
FLOC CHAM.
POLYELECTROLYTE
TUBE SETT.
TO SLUDGE CONCENTRATE (FIG A-7)
PH
MONITOR
TO RIVER
SLUDGE
DRUM
PRELIMINARY SETTLING
DRAGOUT
ACID CLEAN
D.O. REC
CHM WSH
RINS
(EAST SIDE)
ACID/ALKALI RINSES EAST SIDE
SUMP STATION
SOLIDS ONLY (WEST SIDE)
BUFFER
pH ADJUST
H2SO4
NaOH
PH
FLASH MIXING
FLOC CHAM.
POLYELECTROLYTE
TUBE SETTLER
TO SLUDGE CONCENTRATE (FIG A-7)
SETTLE
SUMP STA
SUMP STATION
ACID/ALKALI RINSES (WEST SIDE)
DRAGOUT
ACID CU
D.O. REC
RINS
(WEST SIDE)

FIGURE 7. WASTE TREATMENT SHEMATIC - RIVER DISCHARGE

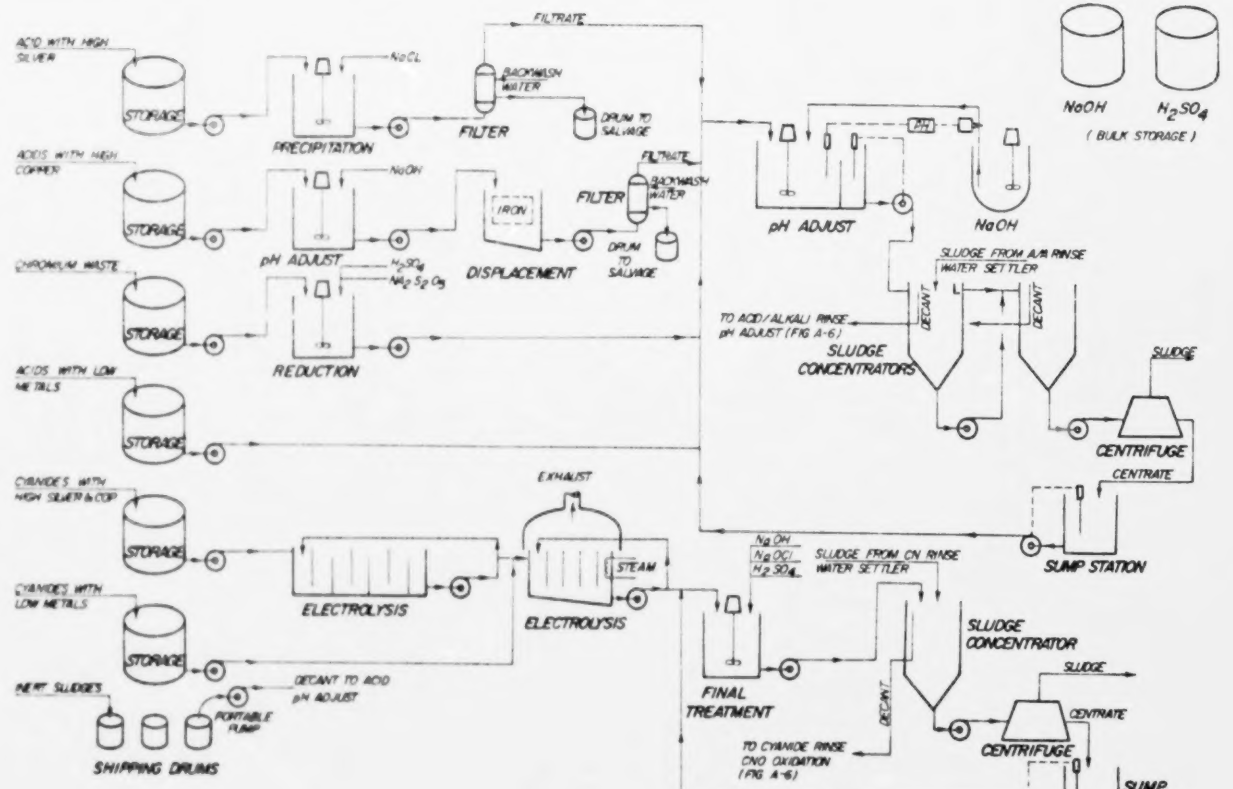

ACID WITH HIGH SILVER
ACIDS WITH HIGH COPPER
CHROMIUM WASTE
ACIDS WITH LOW METALS
CYANIDES WITH HIGH SILVER & COP
CYANIDES WITH LOW METALS
INERT SLUDGES
STORAGE
SHIPPING DRUMS
PORTABLE PUMP
DECANT TO ACID pH ADJUST
PRECIPITATION
NaCL
NaOH
pH ADJUST
H2SO4
Na2 S2 O5
REDUCTION
FILTER
BACKWASH WATER
DRUM TO SALVAGE
FILTRATE
IRON
DISPLACEMENT
ELECTROLYSIS
EXHAUST
STEAM
pH ADJUST
PH
NaOH
H2SO4
(BULK STORAGE)
SLUDGE FROM A/A RINSE WATER SETTLER
DECANT
TO ACID/ALKALI RINSE pH ADJUST (FIG A-6)
SLUDGE CONCENTRATORS
SLUDGE
CENTRIFUGE
CENTRATE
SUMP STATION
NaOH
NaOCl
H2SO4
SLUDGE FROM CN RINSE WATER SETTLER
FINAL TREATMENT
SLUDGE CONCENTRATOR
TO CYANIDE RINSE CNO OXIDATION (FIG A-6)
SLUDGE
CENTRATE
CENTRIFUGE
SUMP STATION

FIGURE 8. BATCH WASTE TREATMENT SCHEMATIC

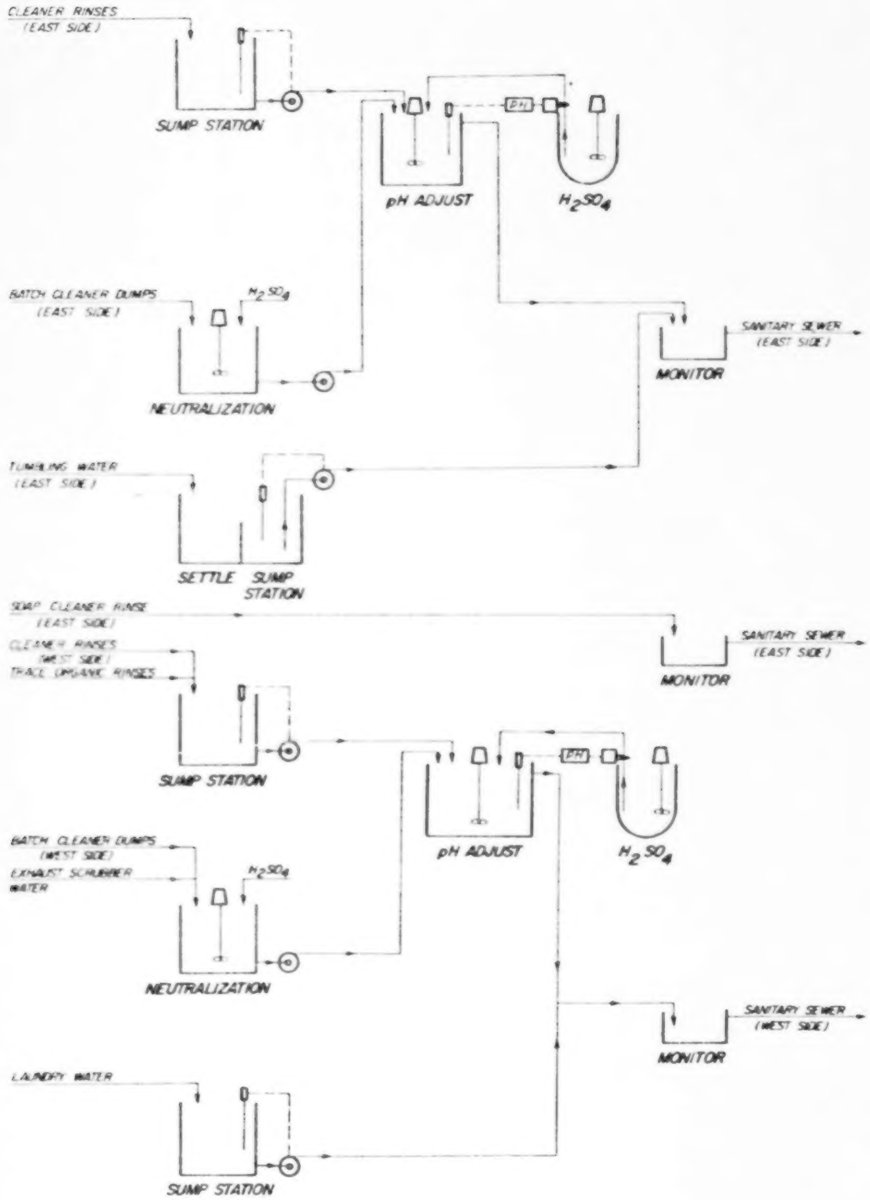

CLEANER RINSES (EAST SIDE)
SUMP STATION
pH
pH ADJUST
H_2SO_4
BATCH CLEANER DUMPS (EAST SIDE)
H_2SO_4
NEUTRALIZATION
SANITARY SEWER (EAST SIDE)
MONITOR
TUMBLING WATER (EAST SIDE)
SETTLE
SUMP STATION
SOAP CLEANER RINSE (EAST SIDE)
SANITARY SEWER (EAST SIDE)
MONITOR
CLEANER RINSES (WEST SIDE)
TRACE ORGANIC RINSES
SUMP STATION
pH
pH ADJUST
H_2SO_4
BATCH CLEANER DUMPS (WEST SIDE)
EXHAUST SCRUBBER WATER
H_2SO_4
NEUTRALIZATION
SANITARY SEWER (WEST SIDE)
MONITOR
LAUNDRY WATER
SUMP STATION

FIGURE 9. WASTE TREATMENT SCHEMATIC - SANITARY SEWER DISCHARGE

chromium to the trivalent state while on the east side of the river. Reduction is accomplished with sodium bisulfite at a reduced pH. The acidic water resulting from this pretreatment step joins other acidic wastewater on the east side of the river for subsequent treatment.

Cementation of flatware on the east side of the river results in a minor amount of wastewater containing inert suspended solids. A preliminary settling step allows for removal of any excess solids that might foul piping systems. The overflow from this settling tank mixes with acid/alkali rinse water for more extensive solids removal.

An acid etch on the east side of the river contains significantly high concentrations of dissolved silver. A dragout recovery step lowers the amount of silver entering the sewer system. Preliminary evaluations indicate that an inline chemical wash will continuously remove virtually all of the dissolved silver. The dragout from this wash station will no longer have significant concentrations of silver. The final water rinse can be considered to be acidic waste that is low in silver and can drain into the other acid/alkali collection system on the east side at the river.

The collection system on the east side of the river for all acid/alkali wastewater (including that discussed in the preceeding three paragraphs) includes means to deliver the wastewater to the west side of the river for treatment. At the centralized treatment site, all acid/alkali rinse waters from both sides of the river combine in a buffer (or equalization) tank.

On the west side of the river there are three general types of acid/alkali rinse water delivered to the aforementioned buffer tank. Wastewater containing solids-only (pumice) pass through a preliminary settling sump for removal of excess solids. Process operations having acid solutions containing high concentrations of dissolved copper and iron will be equipped with dragout recovery stations to reduce the amount of these metals entering the rinse waters. Following the dragout recovery, rinse water can be considered to be similar to those other rinses that are acidic and low in metal content. The third type are those rinses normally low in metal concentrations. All three combine with the acid/alkali water from the east side of the river in the buffer tank located in the centralized treatment site.

The total combined rinses that are classified as acid/alkali flow from the buffer tank into a treatment system for pH adjustment to neutralize excess acids and alkalies. At the same time the hydroxides and oxides of copper, zinc, chromium, iron and nickel are formed. A minor amount of insoluble salts (oxides and hydroxides) of tin and lead are also present. With the pH adjusted to the range of 8.5 to 9.0, these partially treated wastewaters pass through a settler for gravity precipitation of suspended solids. Solids removal is enhanced by the addition of a polyelectrolyte. The sludges removed by settling are concentrated and collected for either salvage or disposal. The clarified overflow from the settler joins with treated waters from cyanide treatment and after passing through a monitoring station discharges to the river.

Rinse Water, Sanitary Discharge--

Rinse waters from alkaline cleaning operations are isolated from all other wastewater. As they pass through a neutralization tank, the pH is adjusted to the range of 9.0 to 9.5 by the addition of sulfuric acid. The water at this point meets the quality criteria for discharge to the sanitary sewer. The water passes through a monitor station prior to final discharge. Due to the great distance between sources of alkaline cleaning and considering the simplicity of treatment, it is proposed to have two of these treatment sites--one on each side of the river, each with its own sanitary sewer connection.

On the east side of the river additional wastewater that is amenable to biodegradation results from tumbling operations. After passing through a settling pit for the removal of excess solids (small metallic particles), this water joins the aforementioned cleaner rinses for discharge via the monitoring station.

At one remote site on the east side of the river (Building 25) a small amount of wastewater containing soap results from cleaning steps. No pH adjustment is required. It is proposed to discharge this wastewater via this building sanitary sewer connection.

Laundry operations produce wash water that is akin to the alkaline cleaner rinses and is discharged via the monitoring station used for cleaners. No pH adjustment is required unless the city water itself is too acidic. If that is the case, then it will discharge via the cleaner rinse neutralization step.

Batch Wastewater--

Alkaline cleaners are transfered to batch holding tanks. Manual addition of sulfuric acid will lower the pH to the range of 9.0 to 9.5. This wastewater will then be metered into the cleaner rinse water systems at a low and controlled rate.

Acid batches that contain high concentrations of silver will have the silver precipitated as the chloride. Filtration will be used to collect the silver chloride, with the filtrate being neutralized as other acids containing low metal values.

Acid batches that contain high concentrations of copper will receive pretreatment to lower the copper concentration by cementation with iron. Preliminary pH adjustment may be necessary for the ferric chloride etch. The displaced copper will be filtered to remove the copper, with the filtrate subsequently being neutralized. Ferric chloride treatment may not be required if negotiations with the supplier to accept return of the spent solution for reclamation are successful.

Chromate batches will be acidified. The hexavalent chromium will be reduced with sodium bisulfite. After reduction the acid is neutralized.

Acids that are low in metal content will be slowly metered through a pH adjustment tank to raise the pH to 8.5 to 9.0. The overflow will be delivered to gravity sludge concentrators. After standing, the clarified water at the top is decanted to the rinse water system. Periodically the partially thickened sludges in the bottom of the concentrator are removed and additional water is removed by use of a centrifuge. The other acids after the pretreatment described in the preceding three paragraphs will be treated in the same manner as the acids that are low in metal.

Batch cyanide wastes that contain high concentrations of silver and/or copper will receive an initial electrolysis at room temperature for extraction of these two metals as metals. After batch electrolysis, when the metal concentration is lowered to approximately 0.5 gm/l, the solution is transferred to a second electrolysis cell. The second batch electrolysis is conducted at elevated temperatures (90-95°C). In this step, although the metals continue to accumulate, the primary function is to oxidize the cyanide to carbon dioxide and nitrogen. When the level of cyanide is lowered to less than 100 mg/l, the electrolysis is considered to be complete. The following chemical oxidation step uses hypochlorite to remove the remaining cyanide. The sludges resulting from high temperature oxidation and chlorination are placed in a concentrator for sludge dewatering. As with the sludges from acid treatment, a centrifuge is used for final dewatering. The sludges are placed in containers and shipped out for salvage values. Cyanides that are low in metal do not receive the low temperature electrolysis and are delivered directly to the high temperature cell.

Sludges result from settling operations in rinse water treatment. The precipitate removed from the settlers is placed in the appropriate concentrator as though they were batch waste. The inert sludges removed from the solids-only pretreatment receive further dewatering by decanting prior to shipping out for disposal.

Floor spills that have been isolated from rinses are treated in the same manner as other batch waste, according to one of the previous seven categories.

Sludges--

Sludges resulting from waste treatment practices are placed in sealed shipping containers or can be removed in bulk. Licensed contractors will be used to ship the material to either an approved disposal site or a refiner.

Unique Wastes--

The "hypo" from photographic rooms will be delivered to the waste treatment area and treated as acids high in silver.

The single operation using mercury is under consideration for elimination. At the present time, when this process is in use, <0.05 mg/l of mercury has been observed in the rinse water at one of the observation manholes. With the concentration effect anticipated by water conservation and segregation of process water from cooling and sanitary water, this value will rise. However, when the process water is combined with that process water presently existing via other manholes, dilution will result in lowering the concentration. It is estimated that the concentration will be less than 0.03 mg/l, a figure that may be acceptable to the receiving waters. If its elimination is considered impractical, the amount entering the rinse water can be reduced by use of dragout recovery techniques. The batch waste resulting from this production operation is minimal. The spent solution and dragout recovery water will be shipped to an approved disposal site.

A minor amount of processing uses tellurium dioxide. The concentration in waste streams has been below detectable limits for this metal. Historically, this process bath is not dumped as a batch discharge. Should its dump become necessary, it will be shipped to an approved disposal site in a manner similar to mercury compounds.

Major Components

Equipment--

The following major equipment items are required to implement the waste treatment facilities:

A. Cyanide Rinses

1. Collection/Transfer
   a. East Side - tank and pump - 200 gallon, duplex pump 18 GPM @ 60' head, level controls, alarm
   b. West Side - tank and pump - 400 gallon, duplex pump 28 GPM @ 30' head, level controls, alarm

2. Buffer
   a. tank - 2500 gallon
   b. mixer - 1/2 HP, 316 SS

3. Treatment/Oxidation of CN
   a. tank - 4500 gallon
   b. mixer - 3 HP, 316 SS
   c. chemical feed/caustic - pH R/C, feed pump, 300 gallon mix tank, 1/3 HP mixer, alarm
   d. chemical feed/hypochlorite - ORP R/C, feed pump, 300 gallon supply tank, alarm

4. Treatment/Oxidation of CNO
   a. tank - 4500 gallon
   b. mixer - 3 HP, 316 SS
   c. chemical feed/caustic and sulfuric - pH R/C, two feed pumps, two 300 gallon mix tanks, two 1/3 HP mixers, alarm
   d. Chemical feed/hypochlorite - pH ORP, feed pump, 300 gallon supply tank, alarm

5. Flocculation/Solids Settling
   a. flocculation/flash mix tank - 200 gallon
   b. flocculation mixer - paddle mechanism, variable speed
   c. flash mixer - 1/3 HP, variable speed
   d. settler - 100 GPM
   e. chemical feed/polymer - feed pump, two 50 gallon mix tanks. two 1/4 HP mixers
   f. sludge pump - 10 GPM

6. Sludge Concentration
   a. tank - 3000 gallon
   b. centrifuge - 10 GPM, 2 HP
   c. centrifuge feed pump - 8 GPM, 1/2 HP
   d. centrate tank and pump - 50 gallon, duplex pumps 5 GPM @ 30' head, level controls

B. Acid/Alkali Rinses

1. Collection/Transfer
   a. West Side - six stations
      1) tank and pump - three 100 gallon, duplex pumps 5 GPM @ 50' head, level controls, alarm
      2) tank and pump - two 100 gallon, duplex pumps 10 GPM @ 50' head, level controls, alarm
      3) tank and pump - 150 gallon, duplex pumps, 15 GPM @ 50' head, level control, alarm
   b. East Side - two stations
      1) tank and pump - 100 gallon, duplex pumps, 5 GPM @ 30' head, level control, alarm
      2) tank and pump - 1000 gallon, duplex pump, 70 GPM @ 60' head, level control, alarm

2. Buffer
   a. tank - 4000 gallon
   b. mixer - 1 HP, 316 SS

3. pH Adjustment
   a. tank - 4000 gallon
   b. mixer - 3 HP, 316 SS
   c. chemical feed/caustic and sulfuric - pH R/C, two feed pumps, two 100 gallon mix tanks, 1/3 HP mixer, alarm

4. Flocculation/Solids Settling
   a. flocculation/flash mix tank - 300 gallon
   b. flocculation mixer - paddle mechanism, variable speed
   c. flash mixer - 1/3 HP, variable speed
   d. settler - 150 GPM
   e. chemical feel/polymer - feed pump, two 100 gallon mix tanks, two 1/3 HP mixers
   f. sludge pump - 10 GPM

5. Sludge Concentration
   a. tank - two 3000 gallon
   b. centrifuge - 10 GPM, 2 HP
   c. centrifuge feed pump - 8 GPM, 1/2 HP
   d. centrate tank and pump - 50 gallon, duplex pumps, 5 GPM @ 30' head, level controls

C. Chromium Rinses

1. Collection/Transfer
   a. tank and pump - 50 gallon, duplex pumps 5 GPM @ 30' head, level controls, alarm

2. Reduction
   a. tank - 250 gallon
   b. mixer - 1/2 HP, 316 SS

    - c. chemical feed/sodium bisulfite - ORP R/C feed pump, 100 gallon mix tank, 1/3 HP mixer, alarm
    - d. chemical feed/sulfuric acid - pH R/C, feed pump, 100 gallon mix tank, 1/3 HP mixer, alarm

D. Solids Only
  1. Collection/Transfer
    - a. East Side - drums - four 55 gallon
    - b. West Side - tank and pump - 500 gallon, duplex pump 10 GPM @ 60' head, level controls, alarm

  2. Solids Settling
    - a. East Side - tank - 270 gallon

E. Cleaner Rinses - East Side
  1. Collection/Transfer
    - a. tank and pump - 150 gallon, duplex pumps 15 GPM @ 30' head, level controls, alarm

  2. pH Adjustment
    - a. tank - 300 gallon
    - b. mixer - 3/4 HP
    - c. chemical feed/sulfuric - pH R/C, feed pump 100 gallon mix tank, 1/3 HP mixer, alarm

F. Cleaner Rinses - West Side
  1. Collection/Transfer - two stations
    - a. tank and pump - two 100 gallon, duplex pump 5 GPM @ 50' head, level controls, alarm

  2. pH Adjustment
    - a. tank - 300 gallon
    - b. mixer - 3/4 HP
    - c. chemical feed/sulfuric - pH R/C, feed pump 100 gallon mix tank, 1/3 HP mixer, alarm

G. Tumbling Water
  1. Settle/Transfer
    - a. tank and pump - 400 gallon, duplex pump 15 GPM @ 60' head, level controls, alarm

H. Batch Cleaner Dumps - East Side
  1. Collection Pump - 30 GPM at 30' head

  2. Neutralization tank - 3000 gallon

  3. Mixer - 1 HP, 316 SS

  4. Pump - metering 1-2 GPM

I. Batch Cleaner Dumps - West Side
   1. Portable pump - 50 GPM @ 30 head
   2. Neutralization tank - 5000 gallon
   3. Mixer - 3HP, 316 SS
   4. Pump - metering 1-2 GPM

J. Laundry Water
   1. pump and tank - 150 gallon, duplex pump 15 GPM @ 30' head, level controls, alarm

K. Acid Etch
   1. East Side - chemical wash system
   2. West Side - dragout recovery tank (4)

L. Acid/High Silver
   1. Collection/Storage/Transfer
      a. drum - two 55 gallon
      b. storage - 100 gallon
      c. pump - 10-15 GPM
   2. Treatment
      a. tank - 100 gallon
      b. mixer - 1/3 HP, 316 SS
      c. filter - bag type 10 ft^3
      d. sludge - storage - 55 gallon

M. Acids/High Copper
   1. Collection/Storage/Transfer
      a. drum - three 55 gallon
      b. storage - 500 gallon
      c. transfer pump - 15 GPM
   2. Treatment
      a. pH adjustment tank - 300 gallon
      b. mixer - 3/4 HP, 316 SS
      c. transfer pump - 15 GPM
      d. displacement tank with rotating cylinder - 400 gallon
      e. filter - 5 GPM
      f. sludge storage - three 55 gallon

N. Chromium Wastes
   1. Collection/Storage/Reduction
      a. drum - three 55 gallon
      b. storage - 500 gallon
      c. reduction tank - 250 gallon
      d. mixer - 1/2 HP, 316 SS
      e. transfer pump - 1-2 GPM

O. Acids/Low Metals
  1. Collection/Storage
    a. portable pump - (same as cleaner)
    b. storage - 1000 gallon
    c. pump - metering 1-2 GPM

  2. pH Adjustment
    a. tank - 500 gallon
    b. mixer - 3/4 HP, 316 SS
    c. chemical feed/caustic - pH R/C, feed pump 100 gallon mix tank, 1/3 HP mixer, alarm
    d. pump and tank - 150 gallon, duplex pumps 15 GPM @ 30' head, level controls, alarm

P. Cyanides/High Silver and Copper
  1. Storage/Transfer
    a. tank - 2000 gallon
    b. pump - 15 GPM 30' head

  2. Electrolysis
    a. high temperature
    b. low temperature

  3. Final Treatment
    a. tank - 600 gallon
    b. mixer - 1/2 HP, 316 SS
    c. pump - metering 1-2 GPM

Q. Cyanides/Low Metal
  1. Tank - 600 gallon
  2. Pump - 2 GPM metering

R. General Items
  1. Bulk Storage Hypochlorite - 3500 gallon
  2. Bulk Storage Caustic - 1500 gallon
  3. Monitor Tank - East Side Sanitary - 100 gallon
  4. Monitor Tank - East Side Cleaners - 150 gallon
  5. Monitor Tank - West Side - 150 gallon
  6. Monitor Tank with pH Recorder - 750 gallon
  7. Drum Pumps - two at 10-15 GPM
  8. Laboratory Control

Installation--

Factors to be considered as a part of the installation include: segregation of cooling water, process water and sanitary water; drain isolation and collection of subtypes; floor construction for isolation and containment of accidental discharges; relocation of existing facilities to allow for space; renovation of existing plant space to accommodate treatment facilities; rigging; plumbing; and electrical.

Space Requirements--

East Side:	
collection/transfer stations	460 square feet
pretreatment for sanitary discharge	115 " "
pretreatment for river discharge	160 " "
West Side:	
collection/transfer stations	700 " "
pretreatment for sanitary discharge	115 " "
treatment for river discharge-rinses	1400 " "
batch treatment - river	2700 " "
Total Space	5650 square feet

Engineering Support--

Technical support for the waste treatment facilities will be provided by both the firm and outside subcontract work to fully develop plans, specifications and details relative to collection systems. Assistance will be required during purchase, installation, operator training, and for general consultation to the project.

Operations--

Labor required to operate and control the facility will be 7000 hr/yr with an additional 1000 hr/yr for maintenance.

Energy requirements are expected to be 58,700 kwh/yr.

Chemical consumption anticipated:

sodium hypochlorite	37,000 gallons/year
caustic soda	56,000 pounds/year
sulfuric acid	8,600 pounds/year
sodium bisulfite	1,900 pounds/year
sodium chloride	100 pounds/year
polyelectrolyte	250 pounds/year

Maintenance items or spare parts should be provided for pumps, mixers, feeders, controls, etc.

Sludge disposal will be required for those sludges that do not have recovery values. The amount anticipated is 550,000 pounds/year (over half results from ferric chloride etchant treatment).

Sewer use and capital recovery charges for discharge to the sanitary sewer should be based upon 7,300,000 gallons/year.

Extramural support may be required for analysis and operation consultation.

Cost Factors

The cost factors relative to capital values represent current (mid-1977) values for equipment. These values relate to the major components just listed for the Primary Design. Volumes of wastewater as given on page 62.

Equipment--

A. Cyanide Rinses	
1. Collection/Transfer	$ 6,600
2. Buffer	2,600
3. Treatment/Oxidation of CN	15,600
4. Treatment/Oxidation of CNO	17,100
5. Flocculation/Solids Settling	25,500
6. Sludge Concentration	14,300
B. Acid/Alkali Rinses	
1. Collection/Transfer	$27,400
2. Buffer	3,800
3. pH Adjustment	10,800
4. Flocculation/Solids Settling	30,800
5. Sludge Concentration	19,800
C. Chromium Rinses	
1. Collection/Transfer	$ 3,100
2. Reduction	11,300
D. Solids Only	$ 4,200

E.	Cleaner Rinses - East Side	
	1. Collection/Transfer	$ 3,200
	2. pH Adjustment	6,800
F.	Cleaner Rinses - West Side	
	1. Collection/Transfer	$ 9,100
	2. pH Adjustment	6,800
G.	Tumbling Water	$ 3,400
H.	Batch Cleaner Dumps - East Side	$ 7,600
I.	Batch Cleaner Dumps - West Side	$ 10,000
J.	Laundry	$ 3,200
K.	Acid Etch	$ 12,000
L.	Acid/High Silver	
	1. Collection/Storage/Transfer	$ 600
	2. Treatment	1,500
M.	Acids/High Copper	
	1. Collection/Storage/Transfer	$ 1,500
	2. Treatment	6,400
N.	Chromium Wastes	
	1. Collection/Storage/Reduction	$ 2,700
O.	Acids/Low Metals	
	1. Collection/Storage	$ 1,500
	2. pH Adjustment	9,600
P.	Cyanides/High Silver and Copper	
	1. Storage/Transfer	$ 2,000
	2. Electrolysis	20,000
	3. Final Treatment	2,100

Q. Cyanides/Low Metal	1,300
R. General Items	11,700
TOTAL EQUIPMENT	$316,000
Installation--	$158,000
Space Required-- (5650 sq. ft.)	$121,500
Engineering--	$ 45,000
Operations--	
Labor	$ 89,200
Energy	3,250
Chemicals	23,000
Maintenance	4,000
Sludge Disposal	8,250
Sewer Use Charge	4,985
Sewer Capital Recovery Charge	910
Extramural Support	5,000
Total Operating Expense	$138,595

ALTERNATIVE DESIGN A-1

The Primary Design considers two discharge points for treated process water: the sanitary sewer for those wastes amenable to biological treatment (see Figure 9) and the river for those wastewaters that do not lend themselves to biodegradation (see Figure 7). This alternative considers total discharge to the sanitary sewer. The waters will require treatment as shown in Figure 7. As shown, these waters combine for monitoring prior to discharge. Additional treatment must be provided in order to meet the Taunton Sewer Ordinance (see Appendix E). This final treatment will consist of filtration prior to discharge. A schematic presentation of the filtration system is provided in Figure 10.

The filters will require a precoat of a filter aid (similar to diatomaceous earth) to insure removal of the remaining 20 mg/l of suspended solids leaving the settling tanks. The filtrate is discharged to the monitoring station prior to sanitary sewer discharge. The backwash water is collected and metered through one of the tube settlers during nonproduction hours. A

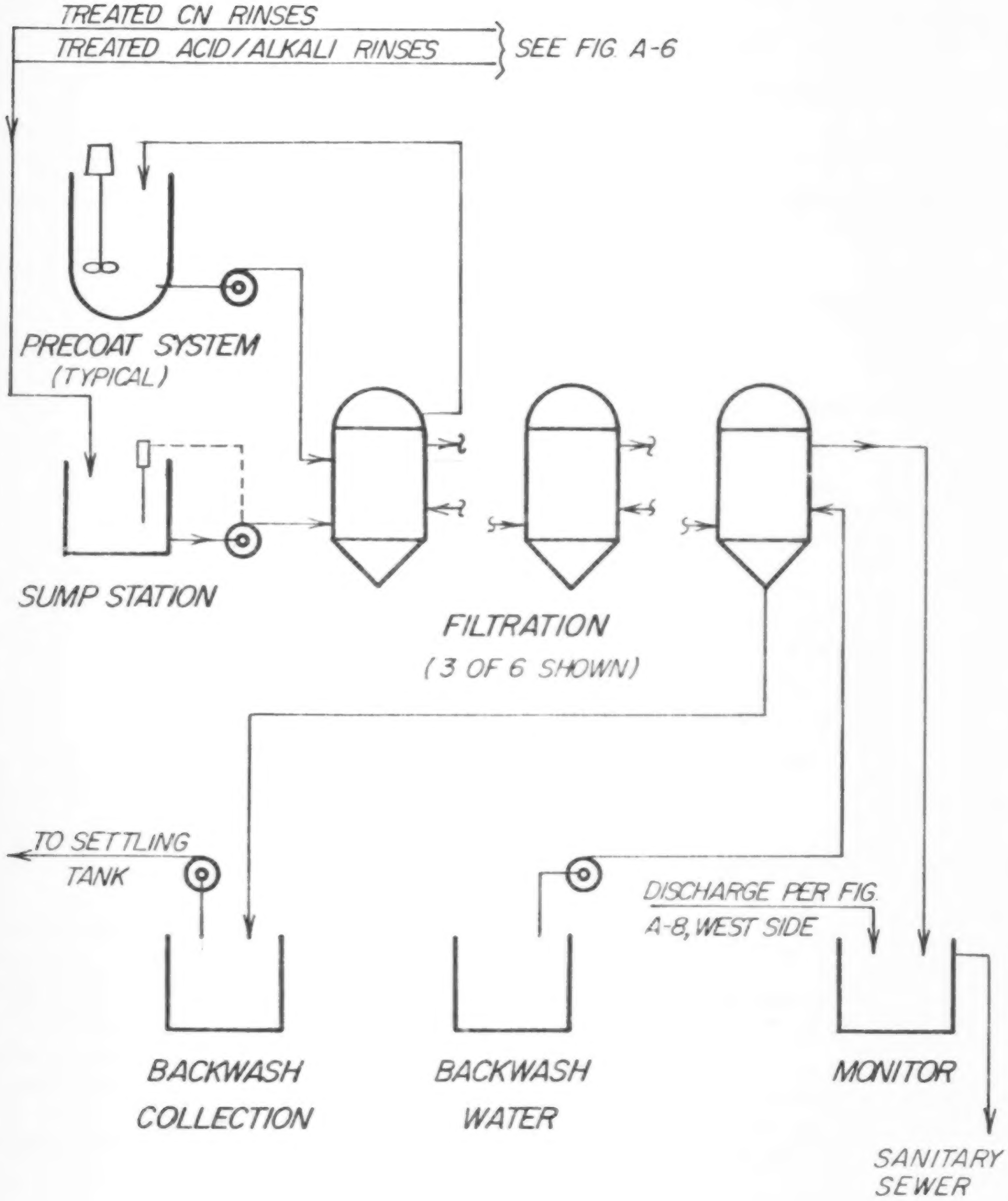

TREATED CN RINSES
TREATED ACID/ALKALI RINSES
SEE FIG. A-6
PRECOAT SYSTEM
(TYPICAL)
SUMP STATION
FILTRATION
(3 OF 6 SHOWN)
TO SETTLING
TANK
DISCHARGE PER FIG.
A-8, WEST SIDE
BACKWASH
COLLECTION
BACKWASH
WATER
MONITOR
SANITARY
SEWER

FIGURE 10. FINAL FILTRATION

number of smaller filters in parallel use permits one to be out of service for backwashing at any one time with the remaining units sized to carry the volume.

Major Components

Using the list as provided under Primary Design, the following incremental items form the basis for cost predictions:

Equipment--

A. Deletions
    1. Stream Monitoring Station

B. Additions
    1. Sump Station - 9000 gallon capacity, duplex 10 HP 300 GPM pumps, controls, alarm
    2. Filter Precoat System - 1000 gallon mix tank, 2 HP mixer, 1 HP recirculation pump
    3. Filters (6) - each at 60 GPM capacity
    4. Backwash Water Reservoir - 1000 gallon capacity
    5. Backwash Pump - 200 GPM, 10 HP
    6. Backwash Collection - 1000 gallon capacity
    7. Backwash Discharge Pump - 5 GPM

C. Alterations
    1. Increase capacity of monitoring tank prior to sanitary sewer from 150 gallons to 1000 gallons
    2. Increase capacity of sludge concentration (see Figure A-7) from 6000 gallons to 9000 gallons by adding a third concentrator

Installation--

Additional space preparation, rigging, plumbing and electrical installation factors must be included for the previous equipment.

Space Requirements--

Space required to house the filtration system will increase the demands for waste treatment equipment by 900 square feet

Operations--

Labor required to operate the filtration system and additional sludge concentration labor will increase by 1000 hours/year and maintenance labor by 200 hours/year.

Energy requirements will increase by 24,000 kwh/year.

Chemical consumption will increase by 5000 pounds/year of filter aid.

Maintenance items will increase with the addition of pumps and filters.

Sludge disposal costs will increase in direct proportion to the amount of solids in the filter aid and the suspended solids. The increase is expected to be 100,000 pounds/year.

Sewer use and capital recovery charges will be increased due to an additional 21,000,000 gallons/year of hydraulic loading.

Cost Factors

The following incremental dollar values should be used to increase (or decrease) values used in the Primary Design:

Equipment--

Deletions	- $ 2,500
Additions	+ $64,400
Alterations	+ $ 6,400
Total Equipment Increase is	$68,300

Installation--	$12,000
Space Requirements--	$21,400

Operations--

Labor	+ $13,400
Energy	+ $ 1,440
Chemical Consumption	+ $ 4,200
Maintenance Items	+ $ 2,500
Sludge Disposal	+ $ 1,450
Sewer Use Charges	+ $19,328
Sewer Capital Recovery Charges	$ 3,529
Total Operating Expenses Increase is	$45,847

ALTERNATIVE DESIGN A-2

The quality of treated wastewater discharging to the river under the Primary Design is sufficiently high to be reused for many cleaning operations. Additional quality improvements can result from filtration to further expand the reuse of treated water. Approximately 40,000 GPD of recycled water is possible without developing excessive distribution costs.

The cost reductions will result in the lower amount of water purchased and sewer use and capital recovery expenses. These savings are offset by the cost of redistributing this quantity of water.

Cost Factors

It is believed that a capital cost of $10,000 will result. Operating costs will be approximately $1,500 per year. Savings from water and sewer costs will amount to $10,670 per year when compared with Alternative Design A-1 and $3,330 per year when compared with the Primary Design.

ALTERNATIVE DESIGN A-3

Certain batch wastes have recovery values for spent solutions and waste treatment sludges. Other batch wastes have negligible recovery values--only expenses attributed to collection, storage, neutralization, sludge dewatering, disposal, etc. If only collection and storage facilities are provided, certain costs can be avoided. However, new costs can be attributed to the subcontract hauling and disposal of the batch wastes having little salvage value.

This design considers treating only the rinse waters. Batch wastes will be collected for disposal via contract haulers and treatment centers.

Refer to Figure 8. Storage facilities will remain for all categories, although acids high in copper, acids with low metals and chromium wastes could be combined. All other categories remain segregated. Acids with high silver content will continue to receive precipitation and filtration. The filtrate is treated as batch acid with low metal content. All other treatment equipment associated with acid wastewater is deleted. Cyanides with high silver and copper content will continue to receive the two stage electrolysis for recovery of metal values. The water discharge from the electrolysis will mix with other cyanides low in metals for collection prior to disposal. The amount of resulting batch waste that is collected for contract disposal is: 41,000 gallons/year of acids and 57,000 gallons/year of cyanides.

In order to optimize bulk shipping charges, the storage tanks will require enlargement. This increase in capital cost is offset by the elimination of treatment equipment as just described. Operating expenses increase for disposal but decrease for labor, energy, maintenance and other associated expenses.

Cost Factors	
Incremental Capital Costs	-$56,000
Incremental Annual Operatin	-$26,600
Annual Cost of Contract Disposal	+$34,000
Net Increase in Operating Expense	+ 7,400

APPENDIX B

POOLE SILVER COMPANY

GENERAL DESCRIPTION

Poole Silver Company, a Division of Towle Manufacturing Company, is located at 320 Whittenton Street in the northern section of Taunton, Massachusetts. Production operations are in a four-story brick building, with two one-floor additions, one two-floor addition, and one three-floor addition. The plant is bordered on three sides by private property and is serviced by sanitary sewers and a storm sewer leading to the Mill River. See Figure 11 for the plant layout. Under normal conditions, there are 150 employees. The major product at this plant is silverplated holloware with brass as a base metal. The second largest product is pewter holloware.

INDUSTRIAL WATER USE

The most predominant use of industrial process water is in cleaning operations for the removal of surface soils and oxides. Wastewater associated with alkaline cleaning results from washing of brass- and pewter-base alloys after solder assembly operations and prior to buffing and polishing steps, as well as prior to electroplating. Wastewater associated with acid cleaning, oxide removal, and surface activation results from pickling in sulfuric acid for scale removal following annealing, bright dip (sulfuric-nitric-hydrochloric acid mixture) of some brass parts, and minor oxide removal prior to electroplating. A minor amount of acid is used for stripping plated parts.

Cyanide processing is used for the electrodeposition of copper and silver, with a minor amount of cyanide gold salts in use. Other less seldom used cyanide process operations include oxidation of silver and stripping of process plating fixtures.

Wastewater also results from steam condensate that is not returned to the boiler, as well as from boiler blowdown.

Cooling water is used in the operation of vapor degreasers and an ultrasonic generator is used to assist in alkaline cleaning.

The above operations that require industrial water use are performed on three floors of Building 1 and the first floors of Buildings 2 and 5. Figure 11, a layout of the total facility, shows the relative locations of these operations. This same drawing shows the discharge point to the sanitary sewer which was used for sampling and analysis. The drain system for the plant intermixes process water, sanitary wastewater and cooling water.

Table 12 shows the various sources of flowing process and cooling water discharged to the outlet.

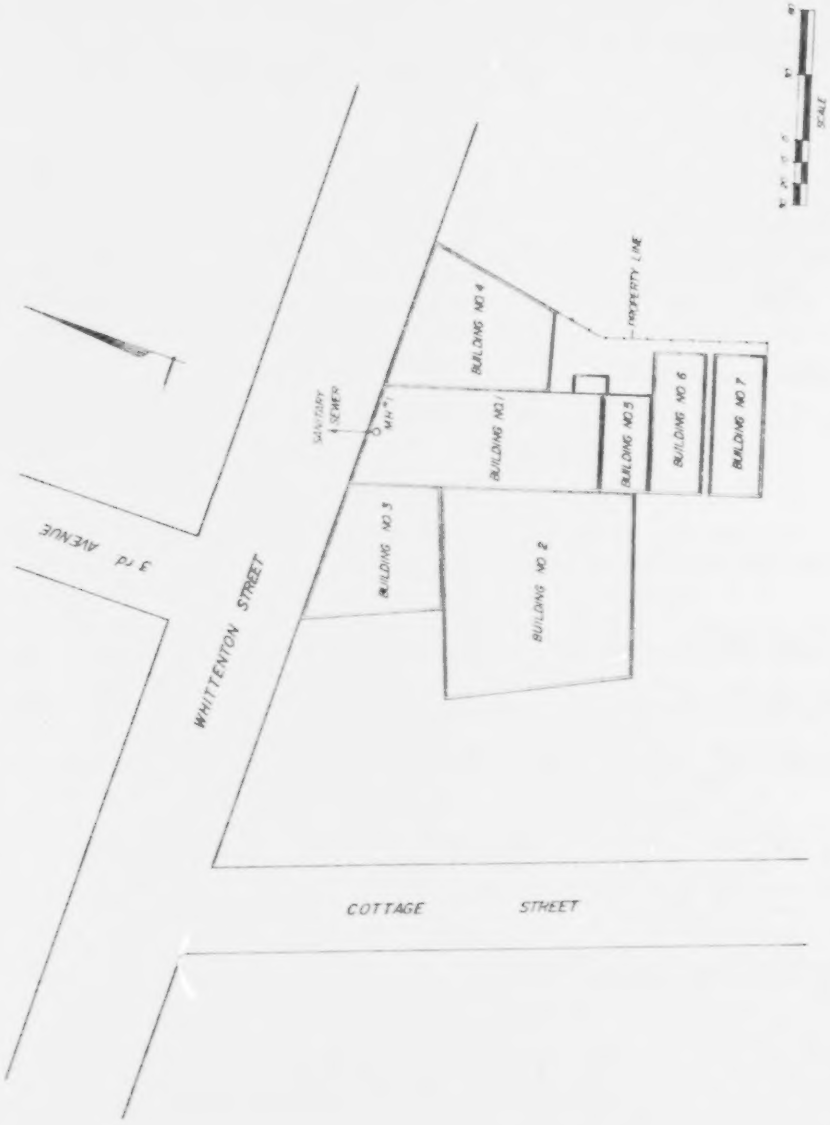

SCALE
PROPERTY LINE
BUILDING NO 4
SANITARY SEWER
MH #1
BUILDING NO 1
BUILDING NO 5
BUILDING NO 6
BUILDING NO 7
3 rd AVENUE
BUILDING NO 3
BUILDING NO 2
WHITTENTON STREET
COTTAGE STREET

FIGURE 11. POOLE SILVER COMPANY - PLANT LAYOUT

TABLE 12. DRAIN SYSTEM - BUILDING 1, 2, TO SANITARY SEWER

Manufacturing Process: Type of Discharge	Rate 1/min	(GPM)	Daily Discharge liters	(gallons)
Soldering Department:				
alkali cleaning	0.8	(0.2)	400	(110)
Pewter Fabrication:				
alkali cleaning	4	(1)	1,900	(500)
cooling water*	14	(3.7)	6,650	(1,780)
Holloware Plating:				
acid/alkali cleaning	115	(30)	57,770	(15,270)
cyanide plating	41	(11)	22,140	(5,850)
cooling water*	19	(5)	10,110	(2,700)
cooling water	40	(10.5)	19,080	(5,040)
Pickle Operation:	16	(4)	7,460	(1,970)

* Used as alkali rinse water.

Figure 12 is an abbreviated flow diagram showing the various types of water discharging to the sewer.

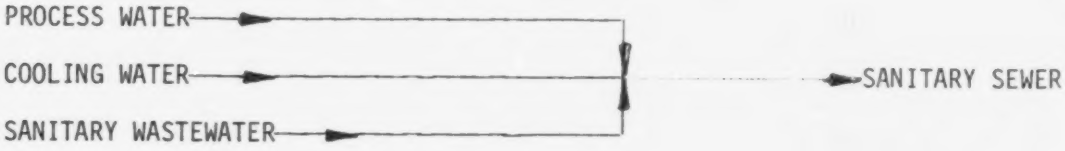


FIGURE 12. WASTEWATER DISCHARGE

Quantity Initially Observed

At the start of this project, some efforts had been directed toward water conservation. Additional effort is presently underway to further reduce the amount of industrial water used. At the time of the initial survey, to establish a data base for this study, it was revealed that the following amount of water was being discharged:

Cooling water = 36,000 l/day (9,500 GPD) at a rate of 73 l/min (19.2 GPM)

Process rinse water = 106,000 l/day (28,200 GPD) at a rate of 210 l/min (55 GPM)

Quality of Discharge

During the year preceding this study, various samples were taken from the discharge to the sanitary sewer. The results of the analysis of these samples are shown in Table 13. Most of the samples were composite samples, but no attempt was made to preserve the cyanide. It is also believed that the analysis reflects more the poor quality of city water in use than the total contamination caused by processing. It is believed that the results are typical of flowing rinse waters that have been diluted by nonprocess water. Some batch dumping of process solutions occurred during sampling periods.

TABLE 13. ANALYSES OF WASTEWATER TO SANITARY SEWER*

Item	Concentration, mg/l	
	Range	Average
Cyanide, Total	0.41 - 7.50	2.98
Cyanide, Amenable	-	-
Copper	1.20 - 6.53	3.89
Silver	1.18 - 6.50	3.93
Zinc	0.02 - 0.25	0.09
Tin	0	0
Lead	0 - 0.50	0.28
Iron	0.51 - 0.73	0.60
Nickel	0	0
Chromium, Total	-	-
Chromium, Hexavalent	-	-
Solids, Suspended	2.0 -11.0	5.6
Solids, Total	154.0 -320.0	201.4
pH, Units	6.0 - 8.2	7.0

* Source: City of Taunton, May 6, 1976, to October 14, 1976.
Poole Silver Company, March 15, 1976, to April 23, 1976.

Since these samples were collected, some water and chemical conservation steps have been taken and plumbing changes have resulted. For the purposes of this study, additional average composite samples were collected. The results are shown in Table 14. They are believed to be representative of a typical production day and of present conditions when a minimum of batch dumping occurred. They will serve as a data base for this project.

TABLE 14. ANALYSIS OF WASTEWATER[*]

Item	Concentration mg/l
Cyanide, Total	3.55
Cyanide, Amenable	3.55
Silver	0.73 (0.62)[†]
Copper	2.23 (2.23)
Zinc	0.04 (0.04)
Tin	< 0.01
Lead	0.015 (<0.01)
Nickel	0.03 (<0.01)
Iron	0.40 (0.15)
Chromium[‡]	< 0.01 (<0.01)
Solids, Suspended	8.0
Solids, Total	96.0
pH, Units	6.68

[*] Source: New England Chemical Works, Whittenton Industrial Center, Taunton, Massachusetts, July 29, 1977.

[†] Values given in parenthesis are for dissolved metals.

[‡] No hexavalent chromium.

Production practices during this later sample period held batch dumps of spent process solutions to a minimum in order to obtain a more accurate picture of rinse water contamination. Table 15 shows a summary of batch discharge by type for the plant. Obviously, the concentration of the various contaminants would be higher during these dump periods.

TABLE 15. SUMMARY OF BATCH DISCHARGES BY TYPE

Type	Subtype	Volume	
		Liters/Year	Gallons/Year
Alkali	Concentrated Cleaners	311,790	(82,370)
	Other Cleaners	269,290	(71,140)
	Boiler Blowdown	8,740	(2,310)
	Total Alkali	589,820	(155,820)
Acid	Low Silver Content	28,310	(7,400)
	High Silver Content*	760	(200)
	Total Acid	29,070	(7,600)
Cyanide	Low Silver	214,130	(56,570)
	High Silver*	4,320	(1,140)
	Total Cyanide	218,450	(57,710)
Solvents*		2,810	(740)

* Not to sewer.

Anticipated Segregation and Conservation

Sanitary wastewater discharge will be segregated from industrial use water. The reuse of cooling water as process rinse water will be expanded to include all cooling water. A simplified flow diagram of process water only, resulting from this segregation, is shown in Figure 13.

Counterflow rinsing will reduce the amount of wet process water used in the plating processes. Other conservation techniques will further reduce the amount of process water discharged.

It is anticipated that an overall reduction of water used for processing and cooling applications from 250 l/min (66 GPM) to 132 l/min (35 GPM) is possible.

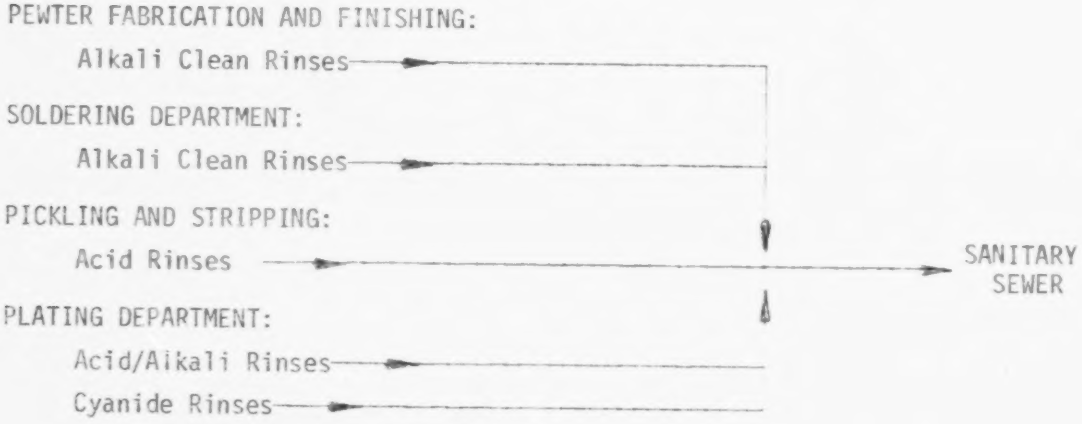

PEWTER FABRICATION AND FINISHING:
Alkali Clean Rinses
SOLDERING DEPARTMENT:
Alkali Clean Rinses
PICKLING AND STRIPPING:
Acid Rinses
SANITARY SEWER
PLATING DEPARTMENT:
Acid/Alkali Rinses
Cyanide Rinses

FIGURE 13. PROCESS RINSE WATER

Anticipated Quality of Raw Waste Discharge

Due to the magnitude of the segregation of sanitary wastewater from indutrial use water together with the water conservation techniques to be employed, it is not possible to accomplish the work before the completion of this project. Also, due to the present intermix of these three types of wastewater, it is not possible to obtain representative samples of wet process wastewater only for analysis. However, it is possible to calculate a theoretical discharge from the analysis obtained for the data base. This theoretical discharge can consider that cooling water is being reused and that water conservation effort will be implemented. Errors will exist in that it is not possible to do more than estimate the amount of water used for sanitary purposes that has a dilution effect. Likewise, it is not practical to include in the contaminant loading those contributions caused by the raw city water.

It is anticipated that all wet process wastewater will be brought to a single location for pretreatment. Weighting the results of analysis in Table 14 with the daily discharge rates in the table showing discharge volumes (Table 12), a value for each contaminant has been predicted and is shown in Table 16. As an estimate, this shows the general order of magnitude for discharge of process wastewater from the total plant.

TABLE 16. THEORETICAL COMBINED PROCESS WATER QUALITY

Item	Concentration, mg/l
Cyanide, Total	5.3
Cyanide, Amenable	5.3
Silver	1.0
Copper	5.5
Zinc	1.3
Lead	0.03
Nickel	0.03
Iron	0.61
Chromium	<0.01

BASIC DESIGN CONCEPT

With the exclusion of cooling water and sanitary wastewater, a more simplified flow diagram has been produced for wet process water. Figure 13 includes segregation by process wastewater streams having common characteristics and/or methods of treatment. Table 14 shows the results of composite samples taken early in the project. Table 16 is a calculated value for the discharge with cooling water excluded. However, these values are considered minimum values since dilution with sanitary waste remains and cyanide is considered low because of intermix with acids prior to sampling.

Segregation of process wastewater will consider two major factors--concentrated batch wastewater will be separated from flowing rinse water, and segregation by treatment required will be accomplished. The analysis results shown in the various tables are in keeping with flowing rinses when batch discharges are kept to a minimum. The concentration in isolated discharge streams having common characteristics can only be estimated as significant alterations to drain systems and are required in order to obtain accurate samples.

Rinses can be segregated into the following two subcategories:

- Acid/alkali, low in salvable metal, and
- Cyanides.

Batch discharges can be segregated into:

- Cleaners, alkaline and detergent type
- Acids, high in metal
- Acids, low in metal
- Cyanides, high in metal
- Cyanides, low in metal.

Acid and alkali rinses will require pH control to minimize heavy metal solubility, followed by removal of the metal hydroxide and/or oxide.

Cyanide-bearing rinses will require oxidation for cyanide removal. In the absence of cyanide, the formerly complexed metals become insoluble. The resulting water following oxidation will combine with the acid/alkali rinse water for pH control and removal of heavy metals.

Considering the segregation methods discussed, Poole Silver Company will have the following types and quantities of flowing rinse water:

acid/alkali rinses	13,000 GPD @ 24 GPM
cyanide rinses	5,500 GPD @ 11 GPM

The flow of process rinse water leaving the plant will be 18,500 GPD at a maximum of 35 GPM.

Spent cleaners, alkaline and detergent type, will be collected in a common holding tank. The pH will be lowered, if required, and metered into the discharge to the sanitary sewer.

Acid dumps having high silver content will be isolated (to simplify recovery) from acids with low recovery values. pH adjustment to neutralize either acid type and precipitate the dissolved metals will result in a sludge that is held for salvage, disposal or further dewatering.

Cyanide batches are normally high in cyanide concentration and dissolved metal. If the metal has salvage value it can be extracted prior to cyanide oxidation. After metal extraction these cyanide batches will be mixed with other cyanide batches that are low in salvable metal. Cyanide oxidation will result in precipitated metal hydroxides and/or oxides. The sludge resulting is held for salvage, disposal or further dewatering.

PRIMARY DESIGN

The design of waste treatment facilities for Poole Silver Company considers current quality criteria, potential regulation by the local and federal authorities, the state of the art of treatment technology, and economies as evident in mid-1977. The primary design, described as follows, considers that the firm might have to resolve its pollution problems totally by itself, and therefore forms the basis for subsequent cost and effectiveness alternatives that might arise by joint participation in any multicompany treatment facility.

Design Criteria

The total volume of process water is expected to be 18,500 GPD and flowing at a maximum rate of 35 GPM. The wastewater is recognized as containing objectionable quantities of cyanide and the heavy metals: copper, zinc and silver. On occasions, the trace metals--tin and lead--are found to be slightly higher than desired. In addition, the pH varies to extremes that exceed the prescribed limits.

A significant portion (57 percent) of the wastewater results from cleaning operations. This water is far more amenable to biological treatment for removal of wetting agents than the remaining waters. Aside from occasional occurances where the pH is too high, the cleaning water exhibits little if any objectionable qualities for discharge to a sanitary sewer system. At the same time the sanitary treatment facilities do provide for removal of the contaminants to the total environment which are present in the cleaning wastewater.

The primary design criteria consider the optimum discharge site for cleaning wastewater to be the sanitary sewer. Other process waters, requiring the removal of cyanide and heavy metals, are considered to have as an optimum discharge site the river (via an existing storm sewer). The quality criteria for discharge to the sanitary sewer in Taunton are more severe than for discharge to the river. Economics indicate a river discharge for this process water.

The high volumes of process wastewater are concerned with flowing rinse water. The rinses are characterized as being relatively low in contaminant concentration. Lesser volumes are associated with the periodic dumping of spent process solutions. The dumps are characterized as being significantly high in contamination, even though low in volume. Two cleaning solutions, containing sodium borate and biodegradable wetting agents, do not fall into the general classification of batch dumps. By their nature, these two solutions used in cleaning steps are considered no more noxious than their rinses and should be considered as cleaner rinses for treatment purposes.

Segregation by type and treatability results in the following three waste streams for rinse water:

- cyanide-bearing rinses at 5,500 GPD at a flow rate of 11 GPM,
- pickle rinses at 2,000 GPD at a flow rate of 4 GPM, and
- alkaline cleaner rinses at 11,000 GPD at a flow rate of 20 GPM.

Batch discharges, requiring disposal techniques that are different from rinses, can be segregated into:

- alkaline cleaners - 6,900 gal/mo.
- acids - 325 gal/mo.
- cyanides - 100 gal/mo.

The quality criteria used as the design basis consider the proposed local ordinance for discharge to the sanitary sewer to be more restrictive than the anticipated Federal Guidelines for Pretreatment. Discharges to the sanitary sewer shall meet the requirements as shown in Appendix E, "City of Taunton Sewer Ordinance."

The quality criteria used as the design basis for discharge to the river consider the requirements of the regulatory agencies in Massachusetts and Region I of the EPA. These requirements are shown in Appendix F, "Water Regulations." It is assumed for the purpose of this report that the antidegradation clause does not apply for this discharge.

Treatment Proposed

Schematic presentations of the proposed treatment systems are shown in Figure 14 for the river discharge and in Figure 15 for the sanitary sewer discharge. A description of the various subsystems is provided:

Rinse Waters--

Cyanide-bearing rinses are isolated from all noncyanide bearing process waters. A two-step chlorination process removes cyanides and cyanates. The resulting water contains copper hydroxide and silver oxide, both of which are present as suspended solids. Gravity settling of suspended solids is provided to reduce these solids to an acceptable level. Solids removal is enhanced by the addition of a coagulant aid. The sludges removed by settling are concentrated and collected for salvage values.

Acid rinse wastewater from pickling, bright dipping and stripping is isolated from other process wastewaters. pH adjustment for neutralization of free acid also results in the formation of copper hydroxide and zinc hydroxide. Trace quantities of oxides and hydroxides of silver, tin and lead are also present in the insoluble state. With the pH adjusted to the range of 8.5 to 9.0, the partially treated wastewater passes through a settler for gravity precipitation of suspended solids. The clarified overflow joins with treated waters from cyanide oxidation, passes through a monitoring station,and discharges to a storm sewer leading to the river. The sludges removed by settling are dewatered and shipped to a disposal site.

Rinse waters from cleaning operations are isolated from all other wastewater. As they pass through a neutralization tank, the pH is adjusted to the range of 9.0 to 9.5 by the addition of sulfuric acid. The water at this point meets the quality criteria for discharge to the sanitary sewer. The water passes through a monitoring tank prior to final discharge.

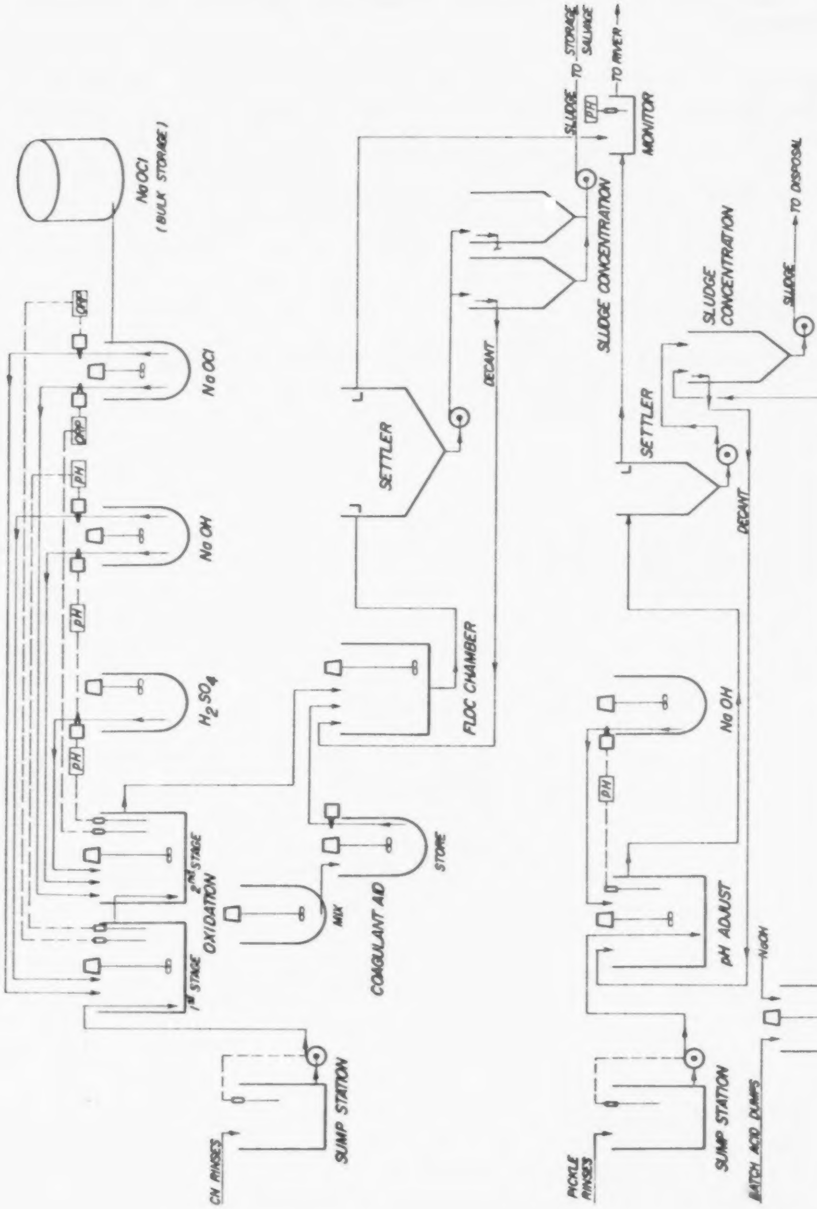

CN RINSES
SUMP STATION
1st STAGE
OXIDATION
2nd STAGE
H2SO4
Na OH
Na OCl
Na OCl
(BULK STORAGE)
pH
ORP
MIX
COAGULANT AID
STORE
FLOC CHAMBER
SETTLER
DECANT
SLUDGE CONCENTRATION
SLUDGE
TO STORAGE SALVAGE
TO RIVER
MONITOR
PICKLE RINSES
SUMP STATION
BATCH ACID DUMPS
NaOH
NEUTRALIZATION
pH ADJUST
Na OH
SETTLER
DECANT
SLUDGE CONCENTRATION
SLUDGE
TO DISPOSAL

FIGURE 14. WASTE TREATMENT SCHEMATIC - RIVER DISCHARGE

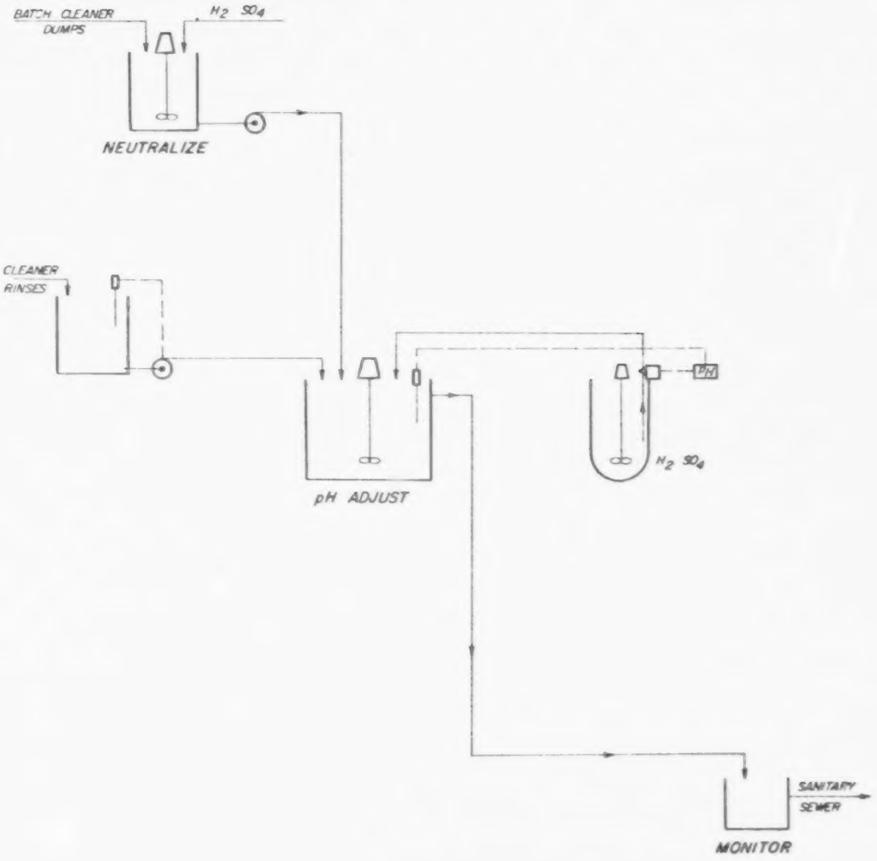

BATCH CLEANER DUMPS
H_2SO_4
NEUTRALIZE
CLEANER RINSES
pH ADJUST
pH
H_2SO_4
SANITARY SEWER
MONITOR

FIGURE 15. WASTE TREATMENT SCHEMATIC - SANITARY SEWER DISCHARGE

Batch Wastewaters--

Alkaline cleaners are transferred to a batch holding tank. Manual additions of sulfuric acid will lower the pH to the range of 9.0 to 9.5. This wastewater will then be metered into the cleaner rinse water system at a low and controlled rate.

Acid batches resulting from pickling, bright dipping and surface activation prior to plating are transferred to the waste treatment area in suitable containers. Periodically, this waste is neutralized in a treatment tank, using caustic soda (sodium hydroxide). The pH is adjusted to the range of 8.5 to 9.0. The resulting hydroxides and oxides of copper, zinc, tin, lead and silver are present as insoluble salts forming a relatively diluted sludge. Retention in a sludge concentrator allows the solids to settle. The clarified water at the top is decanted to the rinse water treatment system for acid-bearing waters. The thickened sludge is removed from the concentrator for either ultimate disposal on landfill or for salvage values.

Acid batches resulting from stripping operations will be shipped out for silver salvage values. In a like manner, cyanide batches resulting from stripping operations will be shipped out for silver salvage values.

Floor spills resulting from accidental discharges will be contained. Treatment will be provided as per other intentional batch discharges.

Sludge Disposal--

Sludges resulting from cyanide oxidation will be shipped out for salvage values. Sludges resulting from acid neutralization will either be sold for salvage values or transported to an approved landfill site.

Major Components

Equipment--

The following major equipment items are required to implement the waste treatment facilities:

A. Cyanide Rinses
  1. Collection/Transfer
    a. tank and pump - 150 gallon, duplex pumps 15 GPM @ 30' head, level controls, alarm

  2. Treatment/Oxidation of CN
    a. tank - 1,000 gallon
    b. mixer - 2 HP, 316 SS
    c. chemical feed/caustic - pH R/C, feed pump, 100 gallon mix tank, 1/4 HP mixer, alarm
    d. chemical feed/hypochlorite - ORP R/C, feed pump, 150 gallon supply tank, alarm

  3. Treatment/Oxidation of CNO
    a. tank - 1,000 gallon
    b. mixer - 2 HP, 316 SS
    c. chemical feed/caustic and sulfuric - pH R/C, two feed pumps, two 100 gallon mix tanks, two 1/4 HP mixers, alarm
    d. chemical feed/hypochlorite - ORP R/C, feed pump, 150 gallon supply tank, alarm

  4. Flocculation
    a. tank - 100 gallon
    b. mixer - 1/3 HP, variable speed
    c. chemical feed/coagulant - feed pump, two 50 gallon tanks, two 1/4 HP mixers

  5. Solids Settling
    a. tank clarifier - 2,800 gallon capacity
    b. sludge pump - 10 GPM

  6. Sludge Concentration/Storage
    a. tanks - two 1,000 gallon
    b. storage tanks - two 500 gallon
    c. sludge pump - 10 GPM

B. Acid Rinses
  1. Collection/Transfer
    a. tank and pump - 150 gallon, duplex pumps 15 GPM @ 30' head, level controls, alarm

2. Treatment/pH Adjust
    a. tank - 100 gallon
    b. mixer - 1/4 HP, 316 SS
    c. chemical feed/caustic - pH R/C, feed pump, 100 gallon mix tank, 1/4 HP mixer, alarm

3. Solids Settling
    a. tank clarifier - 1,000 gallon
    b. sludge pump - 10 GPM

4. Sludge Concentration/Storage
    a. tank - 1,000 gallon
    b. storage tank - 500 gallon

C. Cleaner Rinses

1. Collection/Transfer
    a. tank and pump - 350 gallon, duplex pumps, 30 GPM @ 30' head, level controls, alarm

2. Treatment/pH Adjust
    a. tank - 500 gallon
    b. mixer - 1/2 HP, 316 SS
    c. chemical feed/sulfuric - pH R/C, feed pump, 100 gallon mix tank, 1/4 HP mixer, alarm

D. Cleaner Dumps

1. Transport Containers - four @ 250 gallon
2. Portable Pump - 15 GPM
3. Neutralization Tank - 2,000 gallon
4. Mixer - 2 HP
5. Pump - metering 1 GPM

E. Acid Dumps

1. Transport Containers - four @ 50 gallon
2. Portable Pump - 15 GPM
3. Neutralization Tank - 500 gallon
4. Mixer - 3/4 HP, 316 SS
5. Pump - transfer - 15 GPM @ 30' head

F. General Items

1. Monitor Tank with pH Recorder
2. Monitor Tank for Sanitary Discharge
3. Flow Meters - five
4. Drum Pumps - two
5. Laboratory Control Facilities

Installation--

Factors to be considered as part of the installation include: segregation of cooling water, process water and sanitary water; plumbing changes for reuse of cooling water as process water; floor construction for isolation and containment of wastewater in the plating and pickling areas; relocation of existing facilities to allow for space; renovation of existing plant space to accommodate treatment facilities; rigging; plumbing; and electrical.

Space Requirements--

Collection/Transfer Stations	65 sq. ft.
Sanitary Discharge System	120 sq. ft.
River Discharge System	1175 sq. ft.
Total	1360 sq. ft.

Engineering Support--

Technical assistance is required to develop full plans and specification, supplement the technical staff of the firm during purchase and installation, train operators during start up, and provide general consulting to the project.

Operations--

Labor required to operate and control the facility will be 1600 hr/yr with an additional 400 hr/yr for maintenance labor.

Energy requirements are expected to be 36,000 kwh/yr.

Chemical consumption anticipated:

sodium hypochlorite	10,000 gal/yr
caustic soda	9,600 lb/yr
sulfuric acid	3,800 lb/yr
coagulant aid	20 lb/yr

Maintenance items, or spare parts, should be provided for pumps, mixers, feeders, pH and ORP controls, etc.

Sludge disposal will be required for those sludges that do not have recovery values. The amount anticipated is 25,000 lb/yr.

Sewer use charges for discharge for sanitary sewer should be based upon 2,750,000 gal/yr.

Extramural support may be required for analysis and operation consultation.

Cost Factors

The following dollar values (mid-1977) are believed to represent average values for the major components listed in the preceding section.

Equipment--

A.	Cyanide Rinses	
	1. Collection/Transfer	$ 3,200
	2. Treatment/Oxidation of CN	10,900
	3. Treatment/Oxidation of CNO	12,100
	4. Flocculation	3,000
	5. Solids Settling	3,500
	6. Sludge Concentration/Storage	6,300
B.	Acid Rinses	
	1. Collection/Transfer	3,600
	2. Treatment/pH Adjust	5,400
	3. Solids Settling	2,700
	4. Sludge Concentration/Storage	2,800
C.	Cleaner Rinses	
	1. Collection/Transfer	2,600
	2. Treatment/pH Adjust	6,100
D.	Cleaner Dumps	5,000
E.	Acid Dumps	2,500
F.	General Items	3,500
	TOTAL EQUIPMENT	$73,200

Installation--

Space Preparation	$10,000
Rigging	6,000
Plumbing	8,500
Electrician	7,500
TOTAL INSTALLATION	$32,000

Space Requirements--

The capital value of space is $25,800.

Engineering Support--

It is estimated the fees will be	$10,000

Operations-- (on annual basis)

Labor	$18,780
Energy	1,994
Chemicals	8,500
Maintenance	1,000
Sludge Disposal	980
Sewer Use Charge	1,880
Sewer Capital Recovery Charge	343
Extramural Support	4,500
TOTAL ANNUAL OPERATING EXPENSE	$37,977

ALTERNATIVE DESIGN B-1

The primary design for Poole Silver Company has two discharge points: the sanitary sewer for those wastewaters that are amenable to biological treatment, and the river for wastewaters that do not lend themselves to biodegradation. Alternative B-1 considered total discharge to the sanitary sewer. (Refer to Figures 14 and 15). The water designated as discharging to the sanitary sewer will receive the same treatment. The water shown as discharging to the river on Figure 14 will require the same initial degree of treatment as shown. The stream monitoring station will be replaced with filtration equipment as shown in Figure 16.

The filter requires a precoat with diatomaceous earth type filter aid to insure removal of the remaining 20 mg/l of suspended solids leaving the settling tanks. The filtrate is discharged to the monitoring station prior to sanitary sewer discharge. The backwash water, containing filter aid and metal hydroxides and oxides, will receive batch treatment to concentrate the solids.

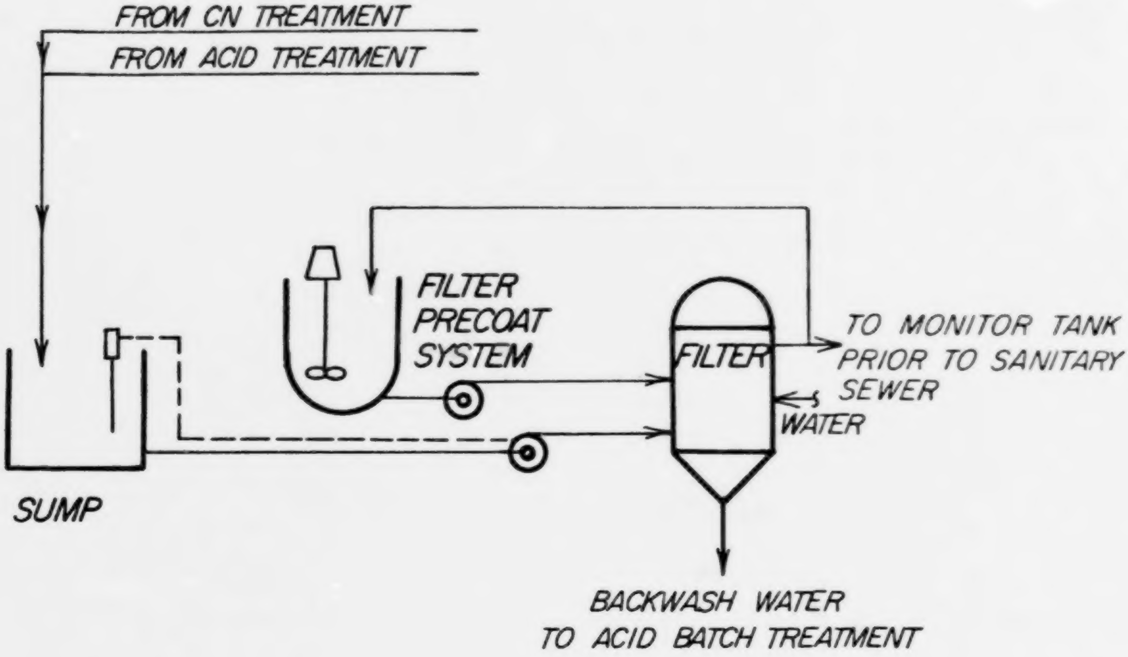

FROM CN TREATMENT
FROM ACID TREATMENT
FILTER
PRECOAT
SYSTEM
FILTER
TO MONITOR TANK
PRIOR TO SANITARY
SEWER
WATER
SUMP
BACKWASH WATER
TO ACID BATCH TREATMENT

FIGURE 16. FINAL FILTRATION

Major Components

Using the list as provided under Primary Design,

Equipment--

1. Deletion
    - a. stream monitoring station

2. Additions
    - a. sump station - 300 gallon, duplex 1 HP pumps, controls, alarm
    - b. filter precoat system - 150 gallon mix tank, 1/3 HP mixer, pump
    - c. filter - 20 GPM capacity

3. Alterations
    - a. increase capacity at monitor tank prior to sanitary sewer from 90 gallon to 150 gallon
    - b. increase capacity of sludge concentrator for acid wastewater from 1,000 gallon to 1,500 gallon

Installation--

Additional space preparation, rigging, plumbing and electrical installation factors must be included in cost assessment.

Space Requirements--

Space requirements will be increased by 104 square feet in the waste treatment area.

Operations--

Labor required to operate the filtration system and additional sludge concentrating labor will increase by 800 hr/yr and maintenance labor by 30 hr/yr.

Energy requirements will increase by 1,900 kwh/yr.

Chemical consumption will increase by 2,500 lb/yr of filter aid.

Maintenance items will increase with the addition of pumps and filter.

Sludge disposal costs will increase in direct proportion to the amount of solids in the filter aid and captured suspended solids. The increase is expected to be 30,000 lb/yr.

Sewer use and capital recovery charges will be increased due to an additional 2,000,000 gal/yr of hydraulic loading.

Cost Factors

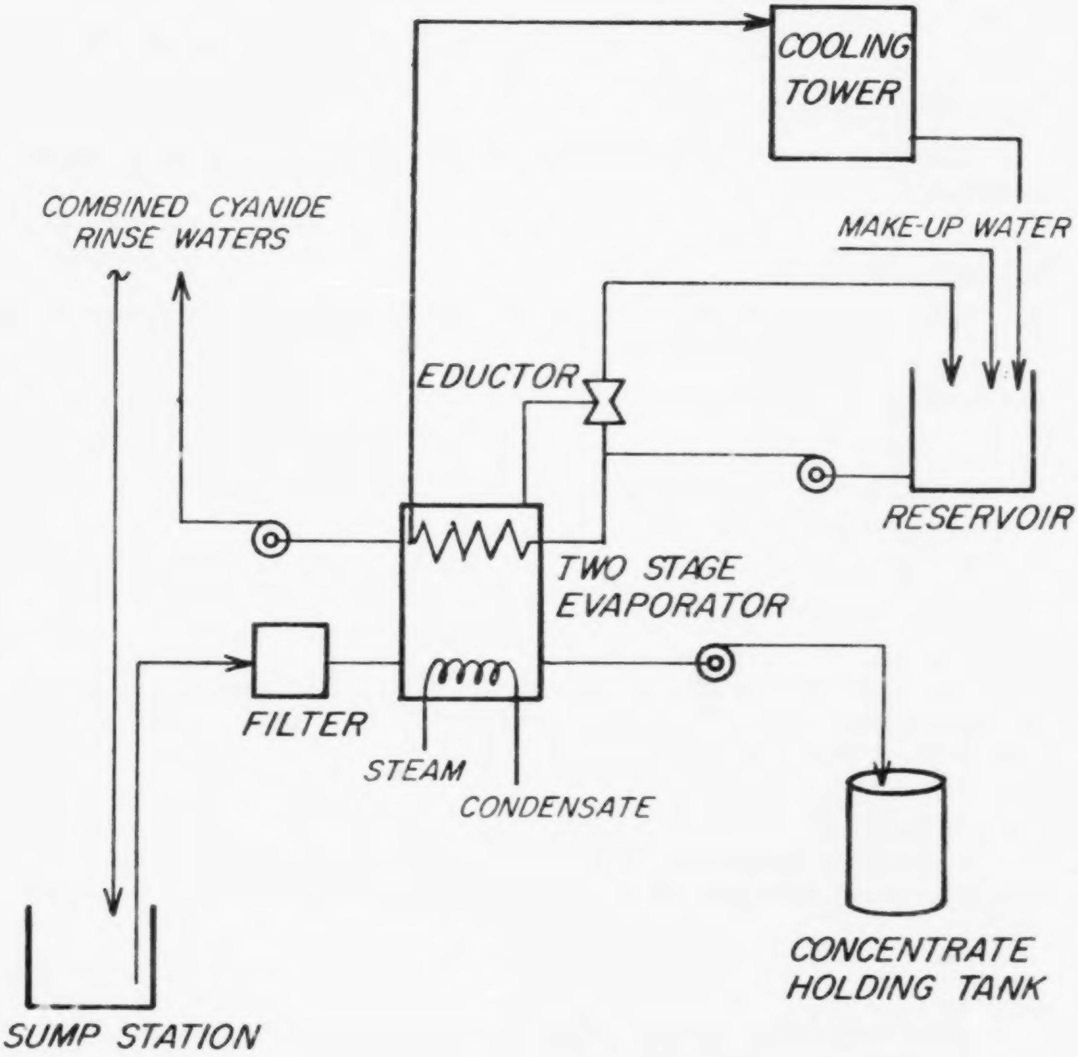
The following incremental dollar values should be used to increase (or decrease) values used in the Primary Design:

Equipment--	
Deletions	-$ 150
Additions	+ 14,200
Alterations	+ 850
TOTAL EQUIPMENT INCREASE	+$14,900
Installation--	+$ 2,500
Space Requirements--	+$ 2,000
Operations-- (on annual basis)	
Labor	+$ 7,800
Energy	+ 105
Chemical Consumption	+ 2,100
Maintenance Items	+ 200
Sludge Disposal	+ 1,170
Sewer Use Charge	+ 1,366
Sewer Capital Recovery Charge	249
TOTAL ANNUAL OPERATING EXPENSES INCREASE IS	$12,990

ALTERNATIVE DESIGN B-2

Evaporative recovery can be used to recycle the rinse waters after cyanide processing. Under this concept, the water used for rinsing is recovered and reused. The concentrate resulting from evaporation is the accumulation of floor spills and dragout from copper and silver plating and other cyanide processing. The volume involved is not sufficient to segregate and install separate evaporators for each source of cyanide. The concentrate is treated as batch waste for disposal and salvage. Counterflow rinses will be installed following copper plating and silver plating steps in order to reduce the volume of water required for plating quality. It is believed that a reduction to 2.5 GPM will result.

In referring to Figure 14, note that section of the schematic flow diagram representing cyanide treatment will be eliminated. The evaporation equipment used is shown schematically in Figure 17. The combined cyanide wastewaters drain into a sump. As the evaporator operates under a vacuum, no feed pump is required. The filter on the inlet to the evaporator removes small solids that might foul the heating coils and the concentrate collection


COOLING TOWER
COMBINED CYANIDE RINSE WATERS
MAKE-UP WATER
EDUCTOR
RESERVOIR
TWO STAGE EVAPORATOR
FILTER
STEAM
CONDENSATE
CONCENTRATE HOLDING TANK
SUMP STATION

(Courtesy Wastesaver™ Corporation)

FIGURE 17. EVAPORATIVE RECOVERY

pans. A pump recirculates water from a reservoir tank, through an eductor to produce the vacuum required and back to the reservoir. This same pump will be used to recirculate the water through a cooling tower. The distillate is pumped back to the various rinse stations to close the loop for rinse waters. The concentrate is removed and held in storage tanks for batch treatment/disposal/salvage. It is estimated that 2 to 4 GPD of concentrate will be produced.

Major Components

Using the list as provided under Primary Design, incremental dollar values are:

Equipment--

A. Deletions - all items relative to cyanide rinse water treatment (Equipment Items A)

B. Additions

1. Counterflow rinse tanks, one at three stage, one at two stage
2. Collection sumps - two at 750 gallon capacity
3. Evaporator with cooling tower
4. Concentrate collector

Installation--

The costs associated with installing the cyanide oxidation equipment is replaced by the costs of installing the evaporative recovery equipment and its auxiliary hardware.

Space Required--

The cyanide oxidation system requires 520 square feet. The evaporative recovery system requires 140 square feet. A net reduction of 380 square feet results.

Operations--

Labor reductions caused by elimination of oxidizing systems is replaced with the equivalent man-hours required by the evaporator system.

Energy Requirements--

The cyanide oxidation system being eliminated would use 26,250 kwh/yr. The evaporator system would use 36,300 kwh/yr. There is a net increase of 10,050 kwh/yr. Approximately 27,500 gallons of oil (No. 2 grade) per year is required to operate the evaporator which consumes 15,000,000 Btu per day.

Chemical Consumption--

Hypochlorite is eliminated. Caustic soda consumption is reduced by 750 pounds per year. Sulfuric acid consumption is reduced by 200 pounds per year. Maintenance items are about the same for both systems ($2 - 300/yr).

No direct sludge disposal costs are attributed to either system, as the volume of sludges resulting from chlorination is equivalent to the volume of evaporator concentrate. Both are shipped out for salvage values.

Sewer use charges and capital recovery costs will be reduced by the amount of water not discharging to the sanitary sewer--that which is recirculated through the evaporative recovery system. These cost factors are only applicable when comparing the cost associated with discharge of these cyanide waters to the sanitary sewer. When compared with the Primary Design, no saving exists. When compared with Alternative B-1, a saving will result which can be compared with Alternative B-2 at a reduction of 1,375,000 gallons per year.

Cost Factors

The following incremental dollars should be used to increase (or decrease) values used in the Primary Design.

Equipment--

Deletions		-$39,000
Additions		+ 52,700
	NET	+$13,700

Installation--

Deletions		-$10,000
Additions		+ 3,000
	NET	-$ 7,000

Space Required--

	NET	-$ 7,200

Operations-- (on annual basis)

Labor	no change
Energy	
electric	+$ 560
fuel oil	+$ 9,900
Chemicals	- 6,650
Sewer Use Charges	- 940
Sewer Capital Recovery Charge	- 172

TOTAL ANNUAL OPERATING EXPENSE INCREASE IS $2,698

ALTERNATIVE DESIGN B-3

Evaporative recovery can also be considered as an alternative to the flow through neutralization of acid rinse waters. The resulting waste product is a concentrate of combined acids that roughly equal the volume of dragout from pickling operation. The flow through treatment expense is eliminated, although increased costs result for batch acid waste disposal (see Primary Design and Alternative Design B-4).

Cost Factors

When compared with the Primary Design the following incremental costs result:

	Reductions (-)/Increases (+)
Equipment	+ $41,000
Installation	- 2,000
Space Required	- 7,200
Operations (on annual basis)	
Labor	0
Energy - Electric	+ 2,258
Fuel	+ 9,900
Chemicals	0
Maintenance Items	0
Sludge Disposal	0
Sewerage Charges	- 420
Sewer Capital Recovery	- 76
Total Operating Expense	+ $11,754

ALTERNATIVE DESIGN B-4

Certain discrete costs can be attributed to the treatment of batch acids--collection, storage, neutralization, sludge dewatering, etc. If only collection and storage facilities are provided, certain costs can be avoided. However, new costs can be attributed to the subcontract hauling and disposals of these batch wastes by others. This alternative summarizes this concept. Refer to Figure 14. The neutralization equipment is eliminated. The sludge concentrator remains the same size as its size is governed more by the sludges resulting from treatment of acid rinses. Sludge disposal costs are reduced. Other costs remain about the same.

Cost Factors

When compared with the Primary Design:

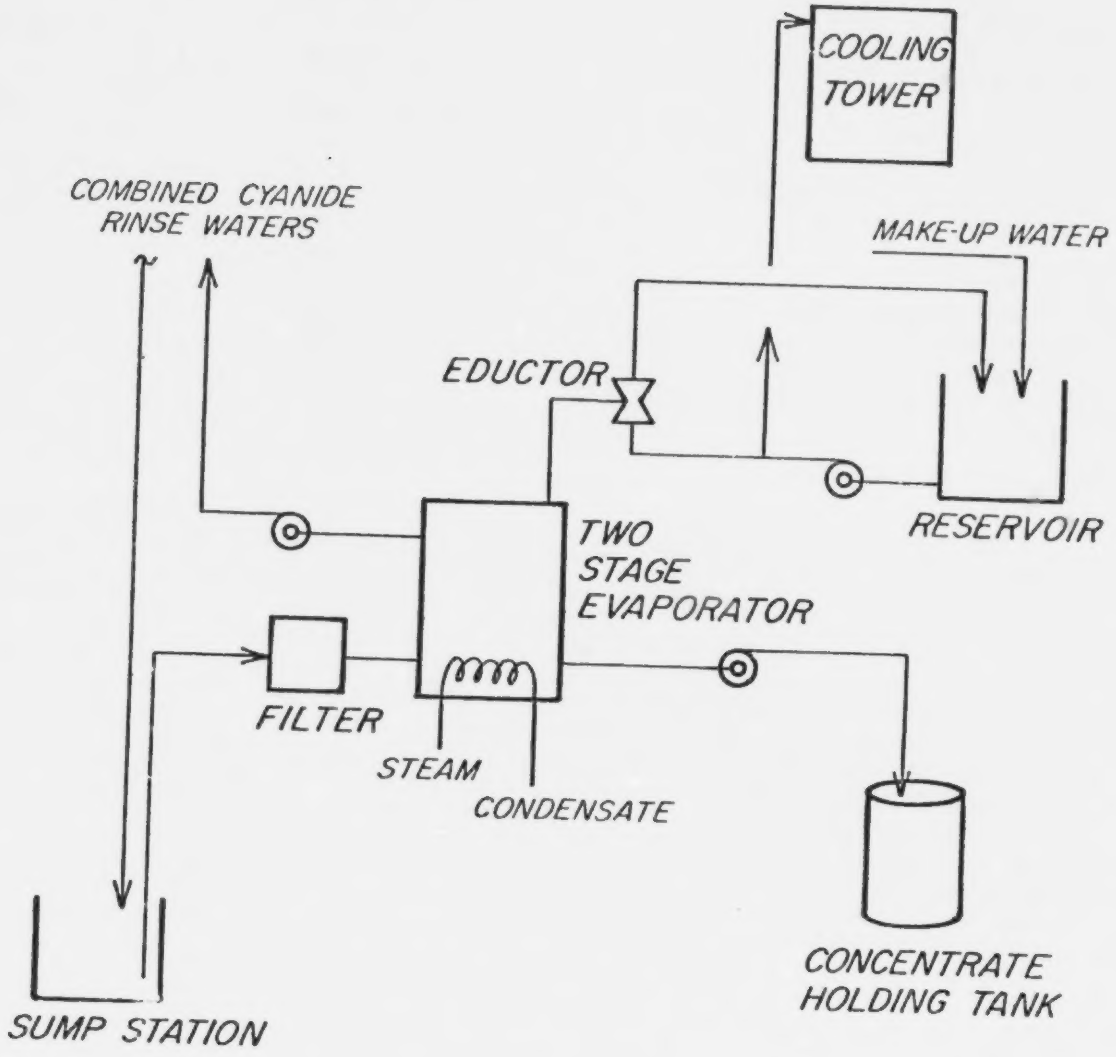
	Reduction (-)/Increase (+)
Equipment	- $1,900
Installation	- 2,000
Space Required	- 400
Operations (on annual basis)	
Labor	- 940
Energy	- 10
Chemicals	- 500
Maintenance Items	- 50
Sludge Disposal	- 800
Hauling & Disposal	+ 2,500
Total Net Operating Expenses	+ $ 200

ALTERNATIVE DESIGN B-5

The treatment of certain wastewaters to meet the stream discharge quality criteria under Primary Design or the filtrate criteria under Alternative Design B-1 are of adequate quality to permit reuse as process water for certain wet process operations. The rinse water volume required for cleaning operations amounts to approximately 11,000 GPD at 20 GPM flow rate. The amount of water resulting from cyanide treatment and acid wastewater treatment is 7,500 GPD at 15 GPM. If appropriate collection and distribution systems are installed, a portion of this treated water can be reused as process water. Under this alternative concept, the sources of process water become a combination of cooling water (9,500 GPD @ 19.2 GPM) and water resulting from cyanide and acid rinse water treatment (7,500 GPD @ 15 GPM). The sum of these to streams exceeds the quantity required for cleaning operations. With the installation of proper recycling equipment and distribution lines, a reduction in water use of about 10,000 GPD will result. Cost reductions in water purchases and sewer use and capital recovery expenses will result. These costs are offset by the cost of redistributing a portion of this treated water.

Cost Factors

It is believed that a capital cost of $5,000 will result. Operating costs will be minimal (less than $250/year).


COOLING TOWER
COMBINED CYANIDE RINSE WATERS
MAKE-UP WATER
EDUCTOR
RESERVOIR
TWO STAGE EVAPORATOR
FILTER
STEAM
CONDENSATE
CONCENTRATE HOLDING TANK
SUMP STATION

(Courtesy Wastesaver Corporation™)

FIGURE 18. EVAPORATIVE RECOVERY

APPENDIX C

F. B. ROGERS SILVER COMPANY

GENERAL DESCRIPTION

F. B. Rogers Silver Company, a wholly-owned subsidiary of National Silver Industries, Inc., is located at 414 West Water Street in the southern portion of Taunton, Massachusetts. Production operations are in a four-story building that was constructed in the early 1900s. The plant, which is approximately 200,000 square feet in size, is serviced by sanitary sewers leading to the municipal sewage plant located about three quarters of a mile downstream on the river. See Figure 19 for plant layout. Under normal conditions, there are 350 employees. The major product at this plant is holloware. Silver-plated brass is the principal process resulting in industrial wastewater. The second largest segment of production using wet processing is nickel alloy-plated brass, which is marketed under the trade name Pewterlite(tm).

INDUSTRIAL WATER USE

Production parts are processed through alkaline cleaning solutions for removal of various soils resulting from mechanical steps: parts cleaned after forming and prior to annealing, after soldering for flux removal, prior to electroplating, and in final finishing. Acid processing is minimal, with acid dipping of some parts required after soldering and for surface activation prior to electroplating. Cyanide solutions are used for copper and silver plating, with a minor amount of cyanide gold salts in use. Cyanide is also associated with stripping of plating fixtures. Process water is also used in mechanical deburring steps that include conventional vibratory and horizontal tumbling techniques. Other plating steps use a modified nickel plating solution, both for a final finish and for a preplate prior to the silverplate.

Steam is purchased from the neighboring power plant for both process solution heating and space heating. All condensate is discharged as wastewater.

Cooling water is used in the operation of vapor degreasers, vacuum pumps, a hydraulic press, an annealing furnace and a gas generator.

Locations

The above operations that require industrial water are performed on four floors of a single building segment identified as Production and Plating areas on Figure 19. Waste treatment prior to discharge to the river is performed at the opposite end of the plant. It will be noted that two of the discharges of process and cooling water are intermixed with sanitary wastewater prior

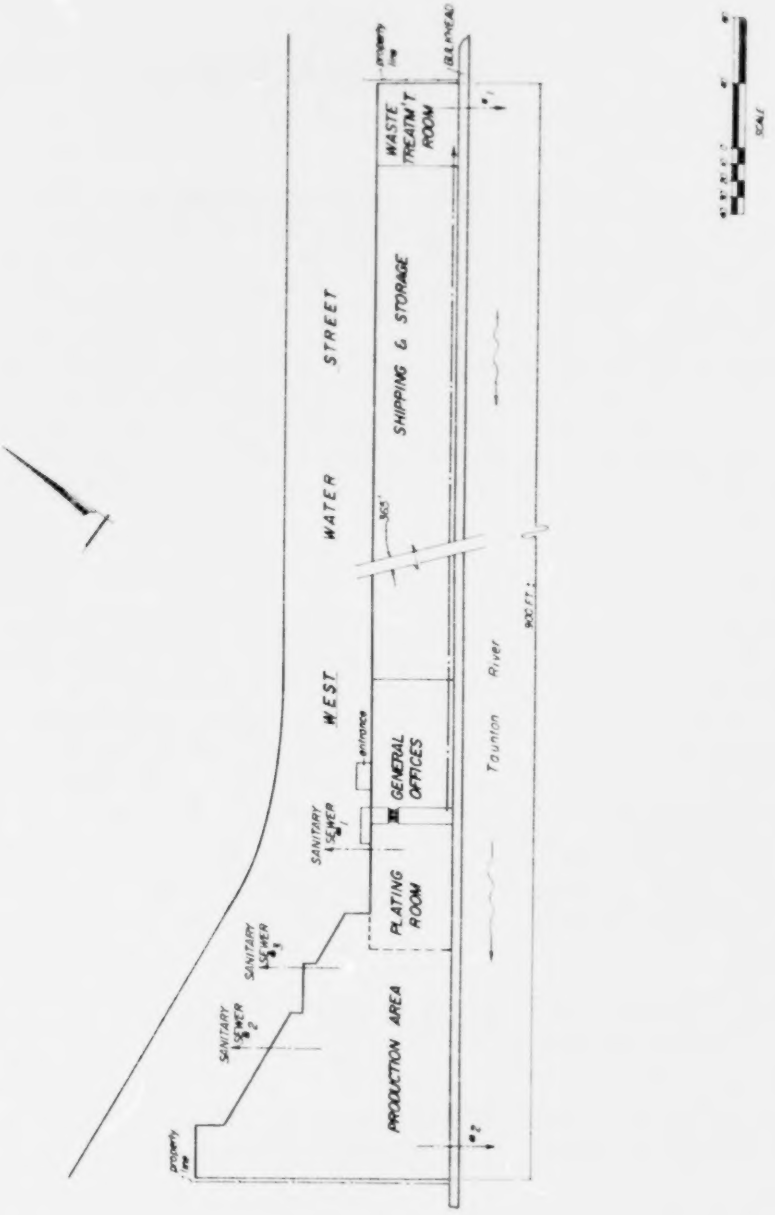

WEST WATER STREET
property line
BULKHEAD
WASTE TREATM'T ROOM
#1
SHIPPING & STORAGE
365'
900 FT ±
Taunton River
entrance
GENERAL OFFICES
SANITARY SEWER #1
PLATING ROOM
SANITARY SEWER #3
SANITARY SEWER #2
PRODUCTION AREA
#2
property line
SCALE

FIGURE 19. F. B. ROGERS SILVER CO., - PLANT LAYOUT

to sewer discharge. Other connections to the sanitary sewer which contain no industrial wastewater are not shown on Figure 19

Sources

Table 17 shows the various sources of flowing process water discharged to each of the outlets. Figure 20 is an abbreviated flow diagram showing the various types of water discharging to each outlet.

TABLE 17. INDUSTRIAL DISCHARGES

Manufacturing Process: Type of Discharge	Rate 1/min	Rate GPM	Daily Discharge Liters	Daily Discharge Gallons
SEWER OUTLET #1 (SSO #1)				
Plating:				
Acid/Alkali Cleaning	95	(25)	64,400	(17,000)
Nickel Plating	19	(5)	18,900	(5,000)
Cooling Water	19	(5)	15,100	(4,000)
SEWER OUTLET #2 (SSO #2)				
Holloware Forming:				
Alkali Cleaning	19	(5)	18,900	(5,000)
Cooling Water	30	(8)	45,400	(12,000)
Buffing:				
Cooling Water	76	(20)	106,000	(28,000)
Tumbling:				
Alkali Cleaning	15	(4)	15,100	(4,000)
SEWER OUTLET #3 (SSO #3)				
Fabrication:				
Acid/Alkali Cleaning	64	(17)	34,100	(9,000)
Final Finishing:				
Alkali Cleaning	26	(7)	22,700	(6,000)
RIVER OUTLET #1 (RO #1)				
Plating:				
Cyanide Rinses	220	(58)	132,000	(35,000)
Final Finishing:				
Cyanide Rinses	19	(5)	18,900	(5,000)

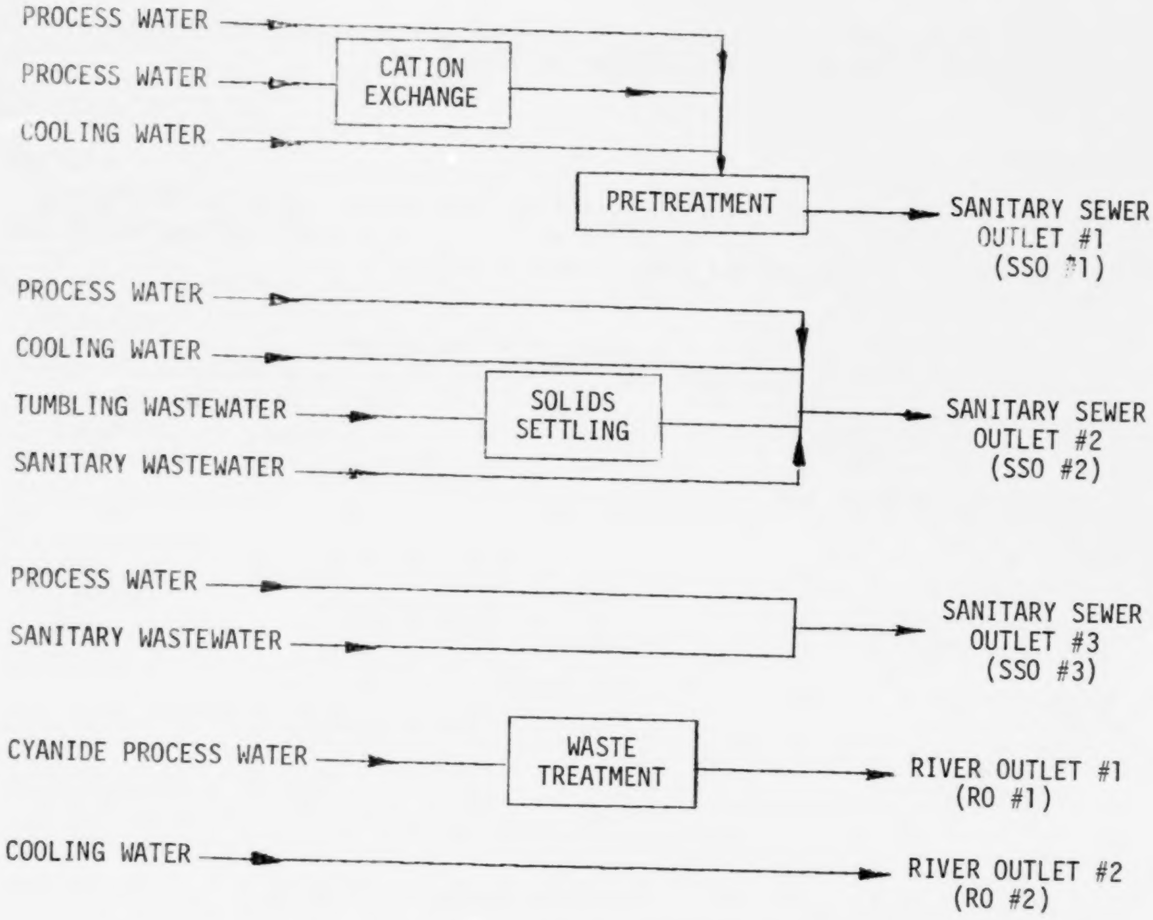

PROCESS WATER
PROCESS WATER
CATION EXCHANGE
COOLING WATER
PRETREATMENT
SANITARY SEWER OUTLET #1 (SSO #1)
PROCESS WATER
COOLING WATER
TUMBLING WASTEWATER
SOLIDS SETTLING
SANITARY WASTEWATER
SANITARY SEWER OUTLET #2 (SSO #2)
PROCESS WATER
SANITARY WASTEWATER
SANITARY SEWER OUTLET #3 (SSO #3)
CYANIDE PROCESS WATER
WASTE TREATMENT
RIVER OUTLET #1 (RO #1)
COOLING WATER
RIVER OUTLET #2 (RO #2)

FIGURE 20. WASTEWATER DISCHARGE POINTS

Existing Treatment Facilities

Unlike the two other firms included in this study, F. B. Rogers Silver Company was faced with resolving its wastewater pollution control problem several years ago (work began in 1972). A treatment system was installed in 1974 under the authorization of the Massachusetts Water Resources Commission. There were two basic discharge points.

River Outlet #1 (RO #1 - see Figure 19) was concerned with discharges to meet the then current regulations for discharge to the waters of the Commonwealth. Cyanide-bearing rinse waters were segregated from noncyanide wastewaters and delivered to the east end of the plant. Waste treatment operations, using a one-step chlorination process followed by gravity settling for removal of suspended solids, were employed to remove cyanide, copper, silver and suspended solids prior to discharge to the Taunton River.

The second major discharge point for wastewater was the sanitary sewer and is identified as Sanitary Sewer Outlet #1 (SSO #1). Most of the non-cyanide process water was combined for pretreatment. Due to the loose restrictions placed on sanitary sewer discharge in 1974, pretreatment was limited to pH adjustment prior to discharge. Rinses known to be high in dissolved nickel were segregated and passed through a cation exchange resin prior to intermixing with other acid/alkali rinse water for pH adjustment.

Backwash and regeneration water resulting from ion exchanger maintenance is batch-neutralized. Sludges resulting (primarily nickel hydroxide) are dewatered, with the clarified water discharging along with treated cyanide wastewater to the river. Additional pretreatment was provided for tumbling wastewater to remove suspended solids that might restrict flow in sewer lines. Those discharges via SSO #2 and #3 were considered innocuous and were believed to meet the then existing sewer ordinances.

In 1975, with the implementation of PL 92-500, an NPDES permit was issued to F. B. Rogers Silver Company. The schedule of compliance called for meeting federal guidelines and revised state regulations by July of 1977 for discharge to the river.

Changes to the treatment system are being put into service during the time this project is being conducted. These changes can be broadly described as:

a. Reduction of metal concentration in the raw waste by conservation techniques in the plating department;

b. Two-step chlorination for oxidation of both cyanide and cyanate;

c. Improved flocculation to promote better suspended solids removal; and

d. Improved performance of clarifiers.

Quantity Initially Observed

At the start of this project, some effort had been directed toward water conservation. Additional effort is presently underway to further reduce the amount of water used. At the time of the initial survey to establish a data base for this study, it was revealed that the following amount of water was being discharged:

Cooling water - 185,000 l/day (49,000 GPD) at a rate of 145 l/min (38 GPM)

Process rinse water - 325,000 l/day (86,000 GPD) at a rate of 477 l/min (126 GPM)

Purchased steam results in 14,000 l/day (3,700 GPD) of condensate for process use during summer periods. Together with space heating during the winter months, 60,000 l/day (16,000 GPD) is the average discharged during a production day.

A breakdown by discharge point for the quantity and rate of flow is provided in Table 18.

TABLE 18. SUMMARY OF INDUSTRIAL WATER FLOW BY OUTLET

Outlet	Rate		Daily Discharge	
	l/min	GPM	Liters	Gallons
Rinse Water:				
SSO #1	114	(30)	83,300	(22,000)
SSO #2	34	(9)	34,100	(9,000)
SSO #3	91	(24)	56,800	(15,000)
RO #1	238	(63)	151,000	(40,000)
Cooling Water:				
SSO #1	19	(5)	15,100	(4,000)
SSO #2	106	(28)	151,000	(40,000)
RO #2	19	(5)	18,900	(5,000)

Quality of Discharge

During the year preceding this study, various samples were taken from SSO #1. The results of the analyses are shown in Table 19. The quality of discharge to the river during the six months preceding this study has been taken from the monthly composite sample analyses as reported under the NPDES permit requirement and is shown in Table 20. It is believed that the quality is typical of flowing rinse water that has been diluted with nonprocess water in the case of the sanitary sewer discharge and of undiluted discharge from waste treatment to the river.

TABLE 19. RESULTS OF PREVIOUS ANALYSES OF WASTEWATER AT SSO #1*

Item	Concentration, mg/l	
	Range	Average
Cyanide	1.9 - 27	13
Silver	0.4 - 6.0	3.9
Copper	2.0 - 10.2	5.5
Zinc	0.3 - 0.8	0.5
Lead	0.2 - 0.9	0.5
Iron	0.4 - 0.9	0.6
Nickel	0.5 - 8.4	3.5
Chromium	<0.01 - 0.06	<0.02
Solids, suspended	N/A	17
pH, units, mean	3.1 - 8.3	5

*Source: City of Taunton: Sewer Department, May 6, 1976 - October 14, 1976

TABLE 20. RESULTS OF PREVIOUS ANALYSES OF WASTEWATER AT RO #1*

Item	Concentration, mg/l†	
	Range	Average
Cyanide, total	0.01 - 0.47	0.11
Cyanide, amenable	0.01 - 0.04	0.02
Copper	0.05 - 4.55	1.76
Silver	0.05 - 0.65	0.16
Nickel	0.05 - 0.28	0.13
Solids, suspended	5 - 84	39.0
pH, units, mean	9.2 - 12.0	9.5

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* Source: F. B. Rogers Silver Company, November 1976, April 1977.

† All but suspended solids are based on filtered samples.

Since the samples discharged to the sanitary sewer were taken, some drain changes have been implemented to combine cyanide-bearing water resulting from final finishing touch-up plating and stripping steps with all other cyanides for oxidation. For the purpose of this study, additional average composite samples were taken. These results are shown in Table 21 for sanitary sewer discharge and for river discharge. They are believed to be representative of present conditions and thus serve as a data base for this project.

Production practices during both sample periods held batch dumps of spent solutions to a minimum. Table 22 shows the quantity of batch discharges by outlet. Table 23 shows a summary of the batch discharge by type for the entire plant. Obviously, the concentration of the various contaminants would be higher during these dump periods.

TABLE 21. ANALYSIS OF WASTEWATER[*]

Item	Concentration, mg/l							
	SSO #1		SSO #2		SSO #3		RO #1	
Cyanide, total	†		0.01		0.2		0.006	
Cyanide, amenable	†		0.002		0.138		0.006	
Silver	0.03	(<0.01)[‡]	0.22	(0.04)	0.30	(0.07)	1.73	(0.05)
Copper	0.82	(0.53)	1.55	(0.05)	0.69	(0.43)	15.4	(1.25)
Zinc	1.10	(0.58)	2.50	(1.40)	0.24	(0.21)	0.31	(0.05)
Tin	<0.1		<0.1		<0.1		<0.1	
Lead	0.25	(<0.01)	<0.1		<0.1		0.03	(<0.01)
Nickel	0.06	(0.01)	0.10	(0.04)	0.08	(0.07)	0.85	(0.17)
Iron	0.68	(0.14)	4.52	(0.26)	1.92	(0.64)	0.32	(0.10)
Chromium[§]	0.22	(<0.01)	<0.01		0.15	0.03)	0.01	(<0.01)
Solids, suspended	18.0		157.0		77.0		24.0	
Solids, total	52.0		884.0		458.0		1,185.0	
pH, units	9.69		7.04		8.34		9.43	

[*] Source: New England Chemical Works, Whittenton Industrial Center, Taunton, MA. June 10, 1977 and August 5, 1977.

[†] Nondetectable.

[‡] Values given in parentheses are for dissolved metals.

[§] No hexavalent chromium.

TABLE 22. BATCH DISCHARGE BY OUTLET

Outlet	Volume, liters/year (gallons/year) Alkalies	Acids	Cyanides
SSO #1*	192,000 (50,000)	3,820 (1,010)	0
SSO #2	6,060 (1,600)	0	0
SSO #3	1,990 (525)	1,140 (300)	0
RO #1	0	90,800 † (24,000)	0
RO #2	0	0	0

* Alkalies and acid are pretreated to pH of 6.5 - 9.5 before discharge to sewer.

† Decantation water resulting from nickel precipitation from cation regeneration water neutralization.

TABLE 23. SUMMARY OF BATCH DISCHARGE BY TYPE

Type	Subtype	Volume liters/year or kg/year	gallons/year or lb/year
Alkali	cleaner	200,000 l	52,800 gals
Acid	low metal	4,969 l	1,310 gals
Cyanide	strip*	54,500 l	14,400 gals
Sludges	tumbling †	1,100 kg	2,400 lbs
	cation regeneration †	26,500 l	7,000 gals
	clarifier*	11,300 - 15,900 kg	24 - 35000 lbs

* Contract haul to salvage.

† Contract haul to disposal.

Anticipated Segregation and Conservation

Sanitary wastewater discharge will be segregated from industrial use water. Cooling water will be either reused as process water or recycled through a cooling tower in order to reduce the amount of cooling water discharged. A simplified flow diagram of process water only, resulting from this segregation, is shown on Figure 21.

Counterflow rinsing may be expanded to reduce the amount of cyanide bearing rinse water requiring treatment. Further expansion of existing counterflow rinsing steps for process waters draining to the sanitary sewer is not considered

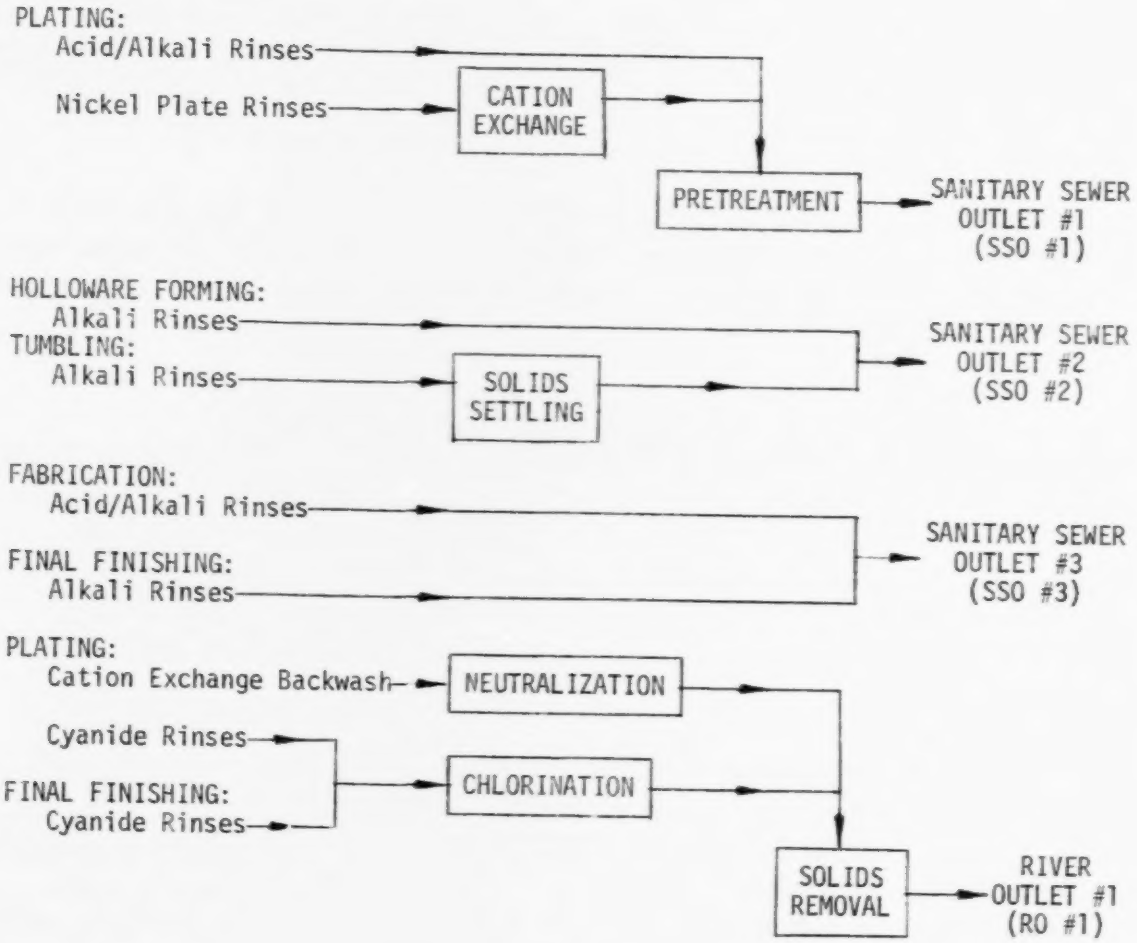
PLATING:
Acid/Alkali Rinses
Nickel Plate Rinses
CATION EXCHANGE
PRETREATMENT
SANITARY SEWER OUTLET #1 (SSO #1)
HOLLOWARE FORMING:
Alkali Rinses
TUMBLING:
Alkali Rinses
SOLIDS SETTLING
SANITARY SEWER OUTLET #2 (SSO #2)
FABRICATION:
Acid/Alkali Rinses
FINAL FINISHING:
Alkali Rinses
SANITARY SEWER OUTLET #3 (SSO #3)
PLATING:
Cation Exchange Backwash
NEUTRALIZATION
Cyanide Rinses
CHLORINATION
FINAL FINISHING:
Cyanide Rinses
SOLIDS REMOVAL
RIVER OUTLET #1 (RO #1)

FIGURE 21. PROCESS RINSE WATER

practical. However, other conservation techniques will result in less process wastewater being used.

All cooling water will be eliminated from direct discharge to the sanitary sewer. This, together with the reduction in process rinse water, will result in a minimum savings of 240,000 l/day (64,000 GPD).

Anticipated Quality of Raw Waste Discharge

It is not possible to segregate cooling water, sanitary wastewater and process water for SSO #2 and #3 in time to obtain quality determinations for isolated process waters. Likewise, the impact of future water conservation efforts cannot be felt in time to be meaningful for qualification of the raw waste requiring treatment.

However, it is possible to calculate a theoretical discharge from the various analyses obtained for the data base. SSO #1 can readily be factored for exclusion of cooling water. The quality from the other outlets receiving cooling water can be factored for the forthcoming exclusion of cooling water. Errors will exist for discharges where it is not possible to do more than estimate the amount of water used for sanitary purposes which has a dilution effect. Likewise, it is not practical to include in the contaminant loading those contributions caused by the raw city water.

It is anticipated that all process wastewater presently discharged to the sanitary sewer and requiring treatment will be brought to a single location for pretreatment. Weighting the results of analysis in Table C-5 with the daily discharge rates in the tables showing discharge volumes to each outlet, a value for each contaminant to be discharged to the sanitary sewer has been predicted and is shown in Table 24. As an estimate this shows the general order of magnitude for discharge from the total plant to the sanitary sewer for process wastewater. The analysis of untreated cyanide bearing rinse waters presently being chlorinated is provided in Table 25. If the full prediction for water conservation in this waste producing operation is realized, the concentration will increase by 50 percent.

TABLE 24. THEORETICAL COMBINED PROCESS WATER QUALITY

Item	Concentration, mg/l
Cyanide, total	0.08
Cyanide, amenable	0.05
Silver	0.28
Copper	1.9
Zinc	2.6
Lead	<0.3
Nickel	0.1
Iron	4.5
Chromium	<0.06

TABLE 25. UNTREATED CYANIDE RINSE WATER

Item	Concentration, mg/l
Cyanide, Total	94.0
Cyanide, Amenable	93.6
Silver	13.1 (12.4)*
Copper	35.7 (33.4)
Zinc	0.55 (0.55)

* Values shown in parentheses are for dissolved metals.

Source: New England Chemical Works, Taunton, Massachusetts, June 21-23, 1977

BASIC DESIGN CONCEPTS

With the exclusion of cooling water and sanitary wastewater, a more simplified flow diagram has been produced for process water. Figure 21 includes segregation by process wastewater streams having common characteristics and/or methods of treatment. Table 21 showed the results of composite samples taken early in this project for major discharge points, and Table 24 presents the calculated values for the discharges without the cooling water. However, the values are considered minimum values since dilution with sanitary waste remains at two discharge points.

Existing segregation for rinses isolates those containing cyanide, those that are high in nickel content, those that result from tumble finishing, and those that result from cleaning. Additional segregation will isolate all batch dumps from rinses. Combining all cleaning rinses for sampling requires extensive alterations to drain systems and is considered impractical at this time.

Rinses can be segregated into the following subcategories:

- acid rinses high in nickel content
- rinses containing cyanides
- rinses from tumbling
- rinses from acid/alkali cleaning

Batch discharges can be segregated into:

- alkaline cleaners
- acids high in metal content
- acids low in metal content
- cyanides high in salvable metal

Acid rinses high in nickel content presently pass through a cation exchanger to produce a low metal content, relatively dilute acid stream. This will be combined with other mildly acidic or alkaline waste streams from cleaning for pH adjustment and heavy metal hydroxide and/or oxide removal.

Rinses following tumbling presently receive settling for partial removal of suspended solids. These will be combined with the preceding pretreated rinses for discharge to the sanitary sewer.

Cyanide-bearing rinses will continue to receive the two-stage chlorination prior to discharge to the river.

Batch alkaline cleaners will be collected in a common holding tank. After pH reduction, if required, they will be metered into the sanitary sewer for discharge.

Acids high in metal content result from ion exchanger backwash and regeneration. The present practice of batch neutralization and precipitation of nickel hydroxide will continue. Acids that are low in metal content will receive similar treatment. Depending upon salvage values of the nickel hydroxide, these other acids may or may not be neutralized separately from the nickel batches. After precipitation, the sludges may be dewatered prior to disposal or salvage.

Cyanides that contain salvable metal are presently shipped out for metal recovery. Due to the small volume involved, this practice probably will be continued.

Considering the segregation methods discussed, F. B. Rogers Silver Company will have the following types and quantities of flowing rinse water:

acid/alkali rinse	33,000 GPD	@ 54 GPM
cyanide rinses	26,000 GPD	@ 40 GPM
nickel plate rinses	5,000 GPD	@ 5 GPM
tumbling rinses	4,000 GPD	

PRIMARY DESIGN

F. B. Rogers Silver Company has installed waste treatment facilities for that portion of its industrial process wastewater that is discharged to the Taunton River. Existing pretreatment facilities will be expanded to meet potential regulations to be established by local and federal authorities. In addition, the design of pretreatment facilities takes into consideration the existing treatment processes, the state-of-the-art of treatment technology and economies as evident in mid-1977. The primary design, described as follows, considers that the firm might have to resolve its pollution problems totally by itself, and therefore forms the basis for subsequent cost and effectiveness alternatives that might arise by joint participation in any multicompany treatment facility.

Design Criteria

The volume of process water discharged to the Taunton River is presently 40,000 GPD and flows at an average rate of 60 GPM. Conservation techniques should reduce this amount by 35 percent. The raw waste contains cyanide, copper, silver and, at times, nickel. The existing waste treatment facility, at the present loading, is operating to meet the requirements of the firm's NPDES permit which was issued jointly by the Commonwealth of Massachusetts and the Environmental Protection Agency, Region I.

The volume of process water discharging to the sanitary sewer is expected to be 42,000 GPD and flowing at a maximum rate of 70 GPM. The wastewater contains objectionable quantities of copper and zinc. On occasions the trace metals, tin and lead, are found to be slightly higher than desired. A minor process using hexavalent chromium has been changed to eliminate this heavy metal. In addition, the pH can vary to extremes that exceed the prescribed limits.

A portion (19 percent of that discharging to the sanitary sewer) of the wastewater results from cleaning operations. This water is far more amenable to biological treatment for removal of wetting agents than the other process waters. Aside from occasional excursions outside the prescribed pH range, the cleaning water exhibits little if any objectionable qualities for discharge to a sanitary sewer system. At the same time, the sanitary treatment facilities do provide for removal of the contaminants to the total environment that are present in the cleaning wastewater.

Seventy percent of the discharge to the sanitary sewer may at times contain objectionable quantities of the heavy metals copper, zinc and nickel. In addition, tumbling wastewater may contain objectionable quantities of metallic solder (tin and lead) particles.

The primary design criteria considers the optimum discharge site for cleaning wastewater and tumbling wastewater to be the sanitary sewer. That portion of the discharge to the sanitary sewer that occasionally contains objectionable amounts of heavy metals also contains wetting agents from plating cleaning steps. The existing facilities used for treatment prior to river discharge does not provide effective removal of these wetters. In addition, the presence of the wetters may interfere with removal of silver oxide prior to river discharge. Therefore, the preferred discharge point for this type of wastewater is the sanitary sewer.

The high volume of process wastewater discharging to the sanitary sewer is concerned with flowing rinse water. The rinses are characterized as being relatively low in contaminant concentration. Lesser volumes are associated with the periodic dumping of spent process solutions. The dumps are characterized as being significantly high in contamination, even though low in volume.

Segregation by type and treatability result in the following waste streams for rinse water:

- cyanide-bearing rinses at 26,000 GPD at a flow rate of 40 GPM,
- nickel-bearing rinses at 5,000 GPD at a flow rate of 5 GPM,
- alkaline cleaning rinses at 25,000 GPD at a flow rate of 37 GPM,
- spray washer (alkaline in nature) wastewater at 8,000 GPD at a flow rate of 17 GPM, and
- tumbling wastewater at 4,000 GPD.

Batch discharges, requiring disposal techniques that are different from rinses, can be segregated into:

- alkaline cleaners - 4,400 gal/mo.
- cation exchanger acids - 2,600 gal/mo.
- other acids - 110 gal/mo.
- cyanides - 1,200 gal/mo.
- inert sludges - 200 lb/mo.
- salvable sludges - 2,500 lb/mo.

The quality criteria used as the design basis considers proposed local ordinance for discharge to the sanitary sewer to be more restricitve than the anticipated Federal Guidelines for Pretreatment. Discharges to the sanitary sewer shall meet the requirements as shown in Appendix E, "City of Taunton Sewer Ordinance."

The quality criteria that was used as the design basis for discharge to the river is that established in the firm's NPDES permit. These requirements are shown in Appendix F, "Regulations for River Discharge."

Treatment Systems

Schematic presentations of the proposed treatment systems are shown in Figure 22 for the river discharge and Figure 23 for the sanitary sewer discharge. A description of the various subsystems is provided:

Rinse Waters--

Cyanide-bearing rinses are isolated from all noncyanide-bearing process water. A two-step chlorination process removes cyanides and cyanates. The resulting water contains copper hydroxide and silver oxide, both of which are present as suspended solids. Gravity settling of suspended solids is provided to reduce these solids to an acceptable level. Solids removal is enhanced by the addition of a coagulant aid. The overflow from solids settling passes through a monitoring tank prior to discharge to the Taunton River. The sludges withdrawn from the clarifier are dewatered by decanting and by use of a centri-

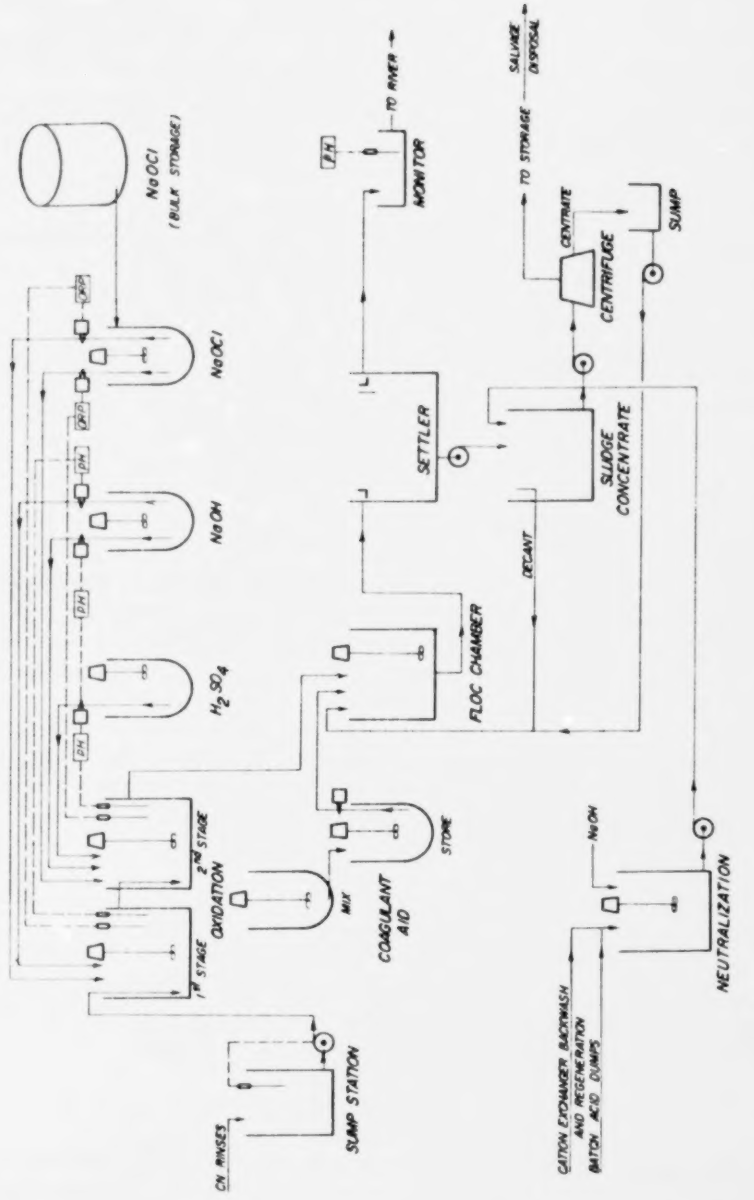
NaOCl
(BULK STORAGE)
ORP
NaOCl
ORP
PH
NaOH
PH
H2SO4
PH
2nd STAGE
1st STAGE
OXIDATION
MIX
COAGULANT AID
STORE
CN RINSES
SUMP STATION
P.H.
MONITOR
TO RIVER
SETTLER
FLOC CHAMBER
DECANT
SLUDGE CONCENTRATE
CENTRATE
CENTRIFUGE
SUMP
TO STORAGE
SALVAGE
DISPOSAL
NaOH
NEUTRALIZATION
CATION EXCHANGER BACKWASH
AND REGENERATION
BATCH ACID DUMPS

FIGURE 22. WASTE TREATMENT SCHEMATIC - RIVER DISCHARGE

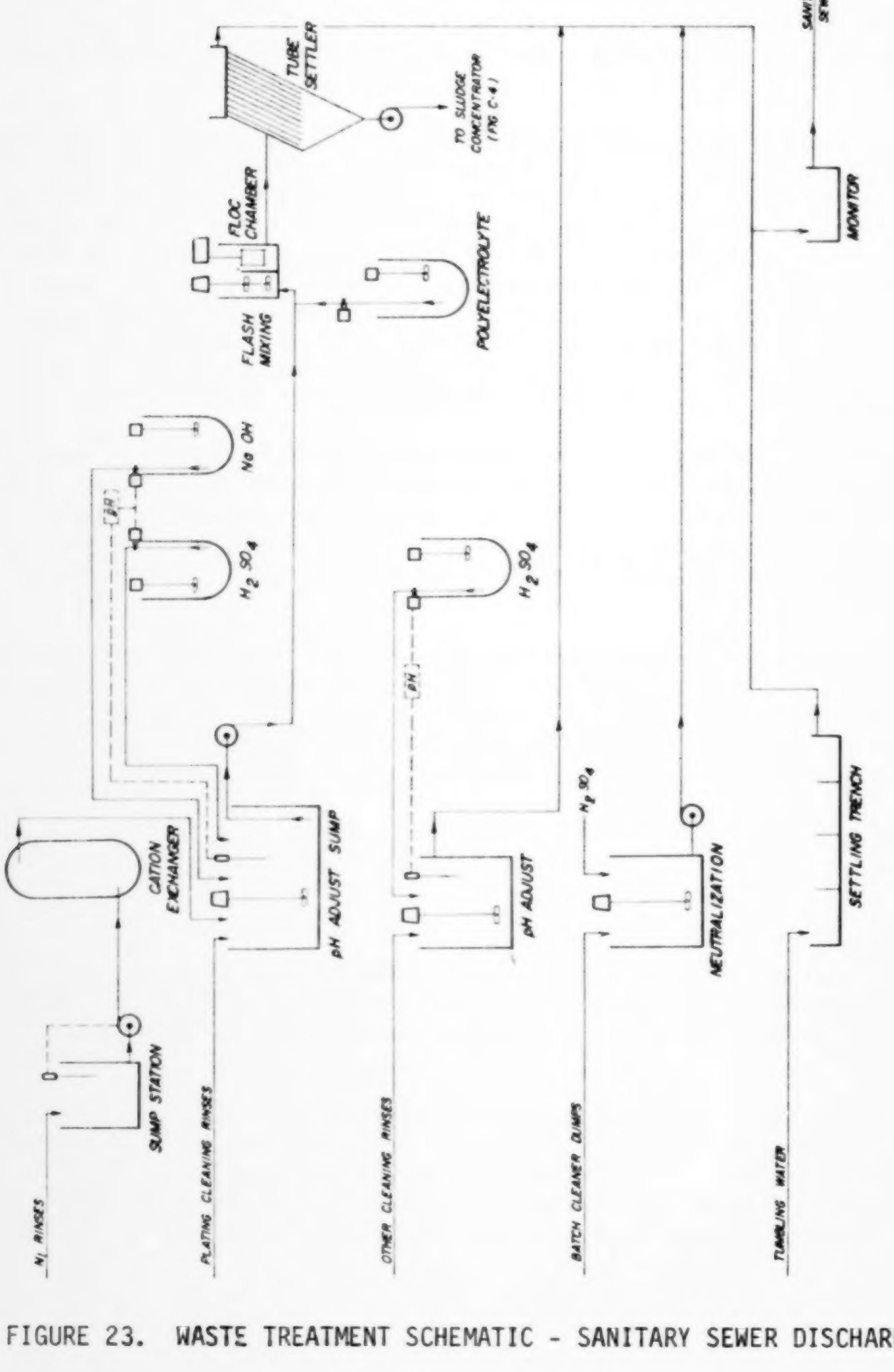
Ni RINSES
SUMP STATION
PLATING CLEANING RINSES
CATION EXCHANGER
pH ADJUST SUMP
pH
H2SO4
Na OH
FLASH MIXING
FLOC CHAMBER
POLYELECTROLYTE
TUBE SETTLER
TO SLUDGE CONCENTRATOR (FIG C-4)
OTHER CLEANING RINSES
pH ADJUST
pH
H2SO4
BATCH CLEANER DUMPS
H2SO4
NEUTRALIZATION
TUMBLING WATER
SETTLING TRENCH
MONITOR
SANITARY SEWER

FIGURE 23. WASTE TREATMENT SCHEMATIC - SANITARY SEWER DISCHARGE

fuge. The water is recycled through the suspended solids removal system. The final sludge is drummed and shipped out for salvage.

Nickel-plating rinses are isolated from other plating wastewater and pass through a cationic resin for removal of dissolved metal. The discharge from this ion exchanger is joined with other acid wastewater for neutralization of acid.

The rinse waters from cleaning and surface activation prior to plating are combined with the nickel-plating rinses for pH adjustment to a range of 8.5 to 9.0 to minimize heavy metal solubility. During this neutralization step, hydroxides of copper and zinc as well as any nickel escaping the ion exchanger are formed. Trace quantities of oxides and hydroxides of silver, tin and lead are also present in the insoluble state. The partially treated wastewater passes through a solids settler for gravity precipitation of suspended solids. A polyelectrolyte is added to enhance settling. The discharge from this treatment system is mixed with other waters for discharge to the sanitary sewer. The sludges resulting from settling are dewatered prior to disposal.

Rinse waters from other cleaning operations have insignificant quantities of dissolved heavy metals. As they pass through a neutralization tank, the pH is adjusted to the range of 9.0 to 9.5 by the addition of sulfuric acid. The water at this point meets the quality criteria for discharge to the sanitary sewer. The water joins with other process water prior to discharge to the sanitary sewer.

Tumbling operations produce wastewaters that are basically soapy water which contain small metallic particles suspended in the water. As the water passes through a baffled trench, the greater portion of these particles fall to the bottom of the trench. The sludges are periodically removed and placed in drums for disposal. The soapy water drains to the sanitary sewer.

All process waters draining to the sanitary sewer are combined and pass through a common monitoring tank prior to leaving the plant.

Batch Wastewaters--

Alkaline cleaners are transferred to a batch holding tank. Manual additions of sulfuric acid will lower the pH to a range of 9.0 to 9.5. This wastewater will then be metered into the combined rinse waters discharging to the sanitary sewer.

Acid batches resulting from surface activation prior to plating and from ion exchange backwash and resin regeneration are transferred to the waste treatment area for treatment. The pH is manually adjusted to 8.5 to 9.0. The resulting sludges of metal hydroxides and oxides are dewatered by decanting and/or centrifuging. These inert sludges are placed in suitable containers for disposal.

Cyanide batches resulting from stripping operations are shipped out for silver salvage values.

Floor spills resulting from accidental discharges will be contained. Treatment will be provided as per other intentional batch discharges.

Sludge Disposal--
Sludges resulting from cyanide oxidation will be shipped out for salvage values. Sludges resulting from acid neutralization and from the settler used in pretreatment prior to sanitary sewer discharge will either be sold for salvage values or transported to an approved landfill site.

Major Components

Equipment--
The following major equipment items are required to implement the full waste treatment facilities. Those items identified with an asterisk (*) are part of the existing waste treatment facilities.

A. Cyanide Rinses*

1. Collection/Transfer
    a. sump and pump - 500 gallon, duplex pumps 50 GPM @ 30' head, level controls, alarm

2. Treatment/Oxidation of CNO
    a. tank - 3,500 gallon
    b. mixer - 3 HP, 316 SS
    c. chemical feed/caustic - pH R/C, feed pump, 150 gallon mix tank, alarm
    d. chemical feed/hypochlorite - ORP R/C, feed pump, 150 gallon supply tank, alarm

3. Treatment/Oxidation of CNO
    a. tank - 4,500 gallon
    b. mixer - s HP, 316 SS
    c. chemical feed/caustic and sulfuric - pH R/C, two feed pumps, two 100 gallon mix tanks, alarm
    d. chemical feed/hypochlorite - ORP R/C, feed pump, 150 gallon Supply tank, alarm

4. Flocculation
    a. tank - 300 gallon
    b. mixer - 3/4 HP, variable speed
    c. chemical feed/coagulant - feed pump, two 50 gallon tanks, two 1/4 HP mixers

5. Solids Settling
    a. tank clarifiers - two 7,000 gallon each
    b. sludge pump - 100 GPM
    c. decant pumps - two @ 6 GPM

6. Sludge Concentration
    a. tank - 2,000 gallon
    b. tank - 1,000 gallon
    c. centrifuge - 10 GPM, 2 HP
    d. centrifuge feed pump - 8 GPM 1/2 HP
    e. centrate sump pumps - two 1/2 HP

B. Nickel Rinses*

1. Collection/Transfer
    a. sump and pump - 500 gallon, duplex pumps 10 GPM at 30' head, level controls, alarm

2. Cation Exchanger - 4 cubic feet capacity

C. Acid/Alkali Rinses

1. Collection Neutralization
    a. floor sump* - 500 gallon
    b. mixer - 1 HP, 316 SS
    c. chemical feed/caustic* and sulfuric - pH R/C, two feed pumps, two 100 gallon mix tanks, 1/4 HP mixer, alarm
    d. transfer pump - duplex, 50 GPM at 30' head, with level control, alarm

2. Solids Settling
    a. tube type settler - 50 GPM capacity
    b. chemical feed/polyelectrolyte - feed pump, 50 gallon mix/storage tank, 1/4 HP mixer
    c. sludge pump - 10 GPM at 30' head

D. Cleaner Rinses

1. pH Adjust
    a. tank - 200 gallon
    b. mixer - 1/2 HP
    c. chemical feed/sulfuric - pH R/C, feed pump, 100 gallon mix tank, 1/4 HP mixer, alarm

E. Tumbling Wastewater*

1. settling trench - 40 cubic feet

F. Cleaner Dumps

1. portable pump - 50 GPM at 30' head
2. neutralization tank - 3000 gallon
3. mixer - 2 HP
4. pump - metering 1-2 GPM

G. Acid Dumps

1. transfer containers - six 50 gallon
2. drum pump - 10 GPM
3. neutralization tank* - 2000 gallon
4. mixer* - 1 HP, 316 SS
5. transfer pump* - 8 GPM, 1/2 HP

H. General Items

1. bulk storage tanks* hypochlorite
2. monitor tank* with pH recorder* - 50 gallon
3. monitor tank for sanitary discharge - 200 gallon
4. drum pumps* - two at 10 GPM
5. flow meters - four
6. laboratory control facilities*

Installation--

Factors to be considered as part of the installation expense include: segregation of cooling water, process water and sanitary water; plumbing changes for reuse of cooling water as process water; relocation of existing plant space to accommodate treatment facilities; rigging; plumbing; and electrical requirements.

Space Requirements--

Existing facilities consume 140 square feet for collection and transfer, 35 square feet for ion exchange, plus 1525 square feet for treatment, making a total of 1700 square feet. This space is primarily dedicated to treatment prior to river discharge. The space required for pretreatment facilities will require an additional 400 square feet.

Engineering Support--

Technical assistance is required to develop full plans and specification, to supplement the technical staff of the firm during purchase and installation, to train operators during startup, and to provide general consulting to the project.

Operations--

Labor required to operate and control the complete facility will be 2000 hours/year with an additional 500 hours/year for maintenance labor. Energy requirements are expected to be 27,100 kwh/year.

Chemical consumption anticipated:

sodium hypochlorite	27,000	gallons/year
caustic soda	4,500	pounds/year
sulfuric acid	2,000	pounds/year
hydrochloric acid	1,500	pounds/year
coagulant aid	100	pounds/year
polyelectrolyte	65	pounds/year
cation resin	1.3	cubic feet/year

Maintenance items, or spare parts, should be provided for pumps, mixers, feeders, controls, etc.

Sludge disposal will be required for those sludges that do not have recovery values. The amount anticipated is 44,000 pounds/year. Sewer use charges for discharge to the sanitary sewer should be based upon 10,500,000 gallons/year.

Extramural support may be required for analysis and operations consultation.

Cost Factors

The cost factors relative to capital values are believed to represent current (mid-1977) values for new facilities as well as replacement value of existing equipment. These values relate to the major components just listed for the Primary Design.

Equipment--

A.	Cyanide Rinses	
	1. Collection/Transfer	$ 3,200
	2. Treatment/oxidation of CN	14,200
	3. Treatment/oxidation of CNO	16,500
	4. Flocculation	3,800
	5. Solids Settling	16,000
	6. Sludge Concentration	14,100
B.	Nickel Rinses	
	1. Collection/Transfer	$ 3,600
	2. Cation Exchange	13,000
C.	Acid/Alkali Rinses	
	1. Collection/Neutralization	13,600
	2. Solids Settling	16,500
D.	Cleaner Rinses	5,900
E.	Tumbling Wastewater	800
F.	Cleaner Dumps	7,200
G.	Acid Dumps	3,800
H.	General Items	7,300
	TOTAL EQUIPMENT COSTS	$139,500

Installation--

Space Preparation	28,000
Rigging	11,000
Plumbing	21,000
Electrical	14,000
TOTAL INSTALLATION	$74,000

Space Requirements--

The capital value of space is $ 63,000

Engineering Support--

It is estimated the fees for the entire project would be $18,000.

Operations (on Annual Basis)--

Labor	$23,500
Energy	1,500
Chemicals	14,200
Maintenance Items	1,500
Sludge Disposal	1,800
Sewer Use Charge	7,170
Sewer Capital Recovery Charge	1,440
Extramural Support	4,500
TOTAL ANNUAL OPERATING EXPENSES	55,610

ALTERNATIVE DESIGN C-1

Unlike the other firms involved in this study, F. B. Rogers has installed treatment facilities for discharge to the Taunton River. Consequently, it is not practical to consider total discharge to the sanitary sewer. No advantages would result--only increased capital and operating costs. However, an alternative does exist relative to increasing the quantity discharge to the river. The water associated with Nickel Rinses (Item B) and Acid/Alkali Rinses (C) could be rerouted to the waste treatment facility at the east end of the plant. This would require essentially the same equipment. However, 30,000 GPD of treated water would be diverted to the river with the result that only 13,000 GPD would be discharged to the sanitary sewer.

Additional cost to implement would be associated with piping only, at an estimated value of $5,000. Cost avoidance by decreasing sewer user and capital recovery would be $5,722 per year.

ALTERNATIVE DESIGN C-2

Certain discrete costs can be attributed to the treatment of batch acids-collection, storage, neutralization, sludge dewatering, etc. If only collection and storage facilities are provided, certain costs can be avoided. New costs can be attributed to the subcontract hauling and disposal of these batch wastes by others. This alternative summarizes this concept. Refer to Figure 22. The neutralization of cation exchanger backwash and regeneration water plus batch acid dumps is eliminated. The sludge concentrator remains as its primary function is sludge handling for the clarifiers. Sludge disposal costs are reduced. Other costs remain nearly the same.

Cost Factors	Reductions (-)/Increases (+)
Equipment, Net	-$ 3,000
Installation, Net	- 2,000
Space Required	- 1,200
Operations (on annual basis)	
Labor	- 230
Energy	- 110
Chemicals	- 500
Sludge Disposal	- 780
Hauling-Disposal Costs	+ 15,000
Total Operating Expense	+$13,380

ALTERNATIVE DESIGN C-3

The quality of treated water in the grouping of waters in Alternative Design C-1 (i.e. Nickel Rinses and Acid/Alkali Rinses) is believed to be adequate to permit reuse for certain cleaning operations. The amount of water available for reuse is 30,000 GPD. At least half of this water can be used in other, less demanding applications for cleaning. A net reduction of water purchased and discharged to the sanitary sewer of 15,000 GPD will result, assuming the installation of proper recycling equipment and distribution lines. This concept is more practical in conjunction with the Primary Design than with Alternative Design C-1 because of piping costs.

Cost Factors

It is believed that a capital cost of $5,000 will result. Operating costs will be minimal (less than $500/year). Savings from water and sewer costs will amount to $2,750 per year.

APPENDIX D

JOINT TREATMENT

Each company has process solutions that are seldom, if ever, dumped as a spent solution. These are the plating baths themselves, used for the deposition of silver, copper and nickel. These solutions have been designed to permit quality control of concentrations and contaminants. A minor amount of wastewater results from maintaining these solutions. Each company also has process solutions that are dumped as spent or contaminated solutions. These solutions represent a much lower capital investment than the plating solutions and are designed with the expectation of each having a finite life. The life of an alkaline cleaner or an acid pickle may vary from company to company, yet each is installed with the concept that they will periodically be discharged as batch wastewater. The containment of accidental discharge and other floor spillage may or may not be considered to be salvable. However, this type of wastewater must also be considered to be batch waste.

The aforementioned batch wastewater resulting from intentional or accidental discharges is characterized as being relatively low in volume and high in contamination. The second major waste classification is rinse waters. The rinse waters result from the flushing from the surfaces of production parts those chemicals that cling to the surfaces as dragout. Their removal is desired to improve the performance and life of subsequent wet process solutions. In addition, final rinsing is required to maintain the quality of the final product. The rinse water is characterized as being high in volume and relatively low in contamination--the converse of batch discharges.

Batch Wastewater--

The following types of batch wastewater resulting from the dumping of spent or contaminated process solutions from two or more firms are included in this study. (Unique solutions are not included in this section of the report.) The quantities shown are the total amount for all three companies, and are the basis for subsequent joint treatment considerations. A brief description of the solutions is also provided.

a. Alkaline Cleaners - 1,300,000 l/yr (346,000 gal/yr) at an average concentration of 30 gm/l (4 oz/gal), these mildly alkaline solutions contain a minor amount of heavy metal contamination. The wetting agents are normally amenable to biological degradation.

b. Acids high in copper and zinc - 20,000 l/yr (5,280 gal/yr) --sulfuric acid pickles, nitric-sulfuric bright dips and ferric chloride etchant--all strongly acidic with high metal concentrations (15-20 gm/l of copper for example).

c. Acids high in silver - 5,090 l/yr (1,350 gal/yr) -- nitric acids at 20 percent by volume containing silver at concentrations as high as 65 gm/l.

d. Acids low in metals - 102,000 l/yr (27,000 gal/yr) --mostly fluoboric acid containing traces of copper, zinc, tin and lead.

e. Cyanides high in silver and copper - 213,000 l/yr (56,400 gal/yr) -- strips, floor spill, plating solution regeneration.

Rinsing Wastewater--

Rinse waters should be isolated from batch wastewater. Further segregation is required for treatment purposes. The combined volumes for two or more firms included in this study after the segregation are shown as:

a. Rinses following cleaners - 124,000 l/day at 200 l/min (32,800 GPD at 53 GPM).

b. Rinses following pickles, etc. - 9,500 l/day at 53 l/min (2,500 GPD at 14 GPM).

c. Rinses following acid/alkalines low in metal - 344,000 l/day at 735 l/min (91,000 GPD at 194 GPM).

d. Rinses following cyanides high in metal - 148,000 l/day at 318 l/min 39,200 GPD at 84 GPM).

e. Rinses following cyanides low in metal - 45,800 l/day at 136 l/min (12,100 GPD at 36 GPM).

f. Rinses with solids only - 26,500 l/day at 151 l/min (7,000 GPD at 40 GPM).

Options Considered

The Primary Design discussed in Appendices A, B and C are based upon each plant providing its own separate treatment facilities. Three major options have been considered for joint participation.

Option I is concerned with all process wastewaters being delivered to a single site for treatment. Option II is concerned with partial treatment being provided at each plant and the remaining at a single site. The third option is an expansion of Option II in that some of the on-site treatment facilities are replaced with equipment designed to concentrate wastes at the source and expand the amount to be treated at the common facility. This option also includes additional companies using the joint facility.

Option I--

The concept of bringing all process wastewaters to a single treatment facility has some obvious advantages. More sophisticated treatment facilities can be employed than could be economically justified at several single locations. Equipment that is only used on a part time basis at a single plant would receive greater utilization with a resulting reduction in applied depreciation. With a greater demand for quality control caused by an enlarged treatment facility, a heavier investment in analytical testing and instrumentation repair can be justified. In considering the manpower to operate a single combined treatment facility, the needs of several companies can be combined relative to operator skills and supervisory expertise. Accountability for the results of treatment also is simplified for a single facility. However, it must be recognized that individual contributors to a joint treatment facility still must be accountable for their individual discharges into the common facility. Most of all, these advantages can be quantified.

The basic disadvantage to this concept, when applied to this particular study, is the bringing of the process wastewaters to a single facility. Figure 24 is a scaled map of Taunton, showing the relative locations of each of the three firms. Reed & Barton Silversmiths has space available which is sorely lacking at the other two firms. Poole Silver Company is nearest to Reed & Barton. The distance between these two companies is 0.45 miles. The shortest route to convey Poole's waste is west on Whittenten Street, south on Cottage Street, west on Britannia Street and into Reed & Barton's property. The waste would have to be transported across Mill River. A conservative estimate to lay drain lines between the two firms is $120,000 for the sewer and $160,000 for a pumping station. Segregation by treatability of the various waste streams could apply at least a three-fold multiplier to this cost. F. B. Rogers Silver Company is approximately three miles from Reed & Barton. The difference in elevation and the rather tortuous path required by the streets in this city would result in many pumping stations. The costs associated with bringing all these wastes together for common treatment is prohibitive. Obviously, where the relative locations for various firms do not present significant investment for collection, then the advantages are not overwhelmed by collection costs.

Option II--

The overwhelming cost disadvantage in common treatment under Option I is caused by the large volumes of rinse waters. Under Option II, the rinse waters would be treated at each individual plant. With the exception of spent alkaline cleaners, all other batch wastewater would be trucked to the common treatment facility. Each plant would have its own internal batch isolation and collection method that would be comparable to that discussed in Appendices A, B and C under Primary Design. However, no batch treatment would be provided--only collection and storage tanks. The batch treatment itself would be done at a common site.

The same advantages as mentioned under Option I can be repeated. Option II has the additional advantage over Option I in that the costs associated with bringing the wastewater to the common facility are reduced. Costs are still associated with the transport of collected batch wastes. This cost factor can be quantified with relative ease. The reduction in costs by eliminating individual company's batch treatment can be estimated. By working with smaller quantities that do not appear continuously, accountability is simplified. When dealing with salvable metals, a well-monitored accounting system is mandatory so that appropriate credits will accrue to the proper source.

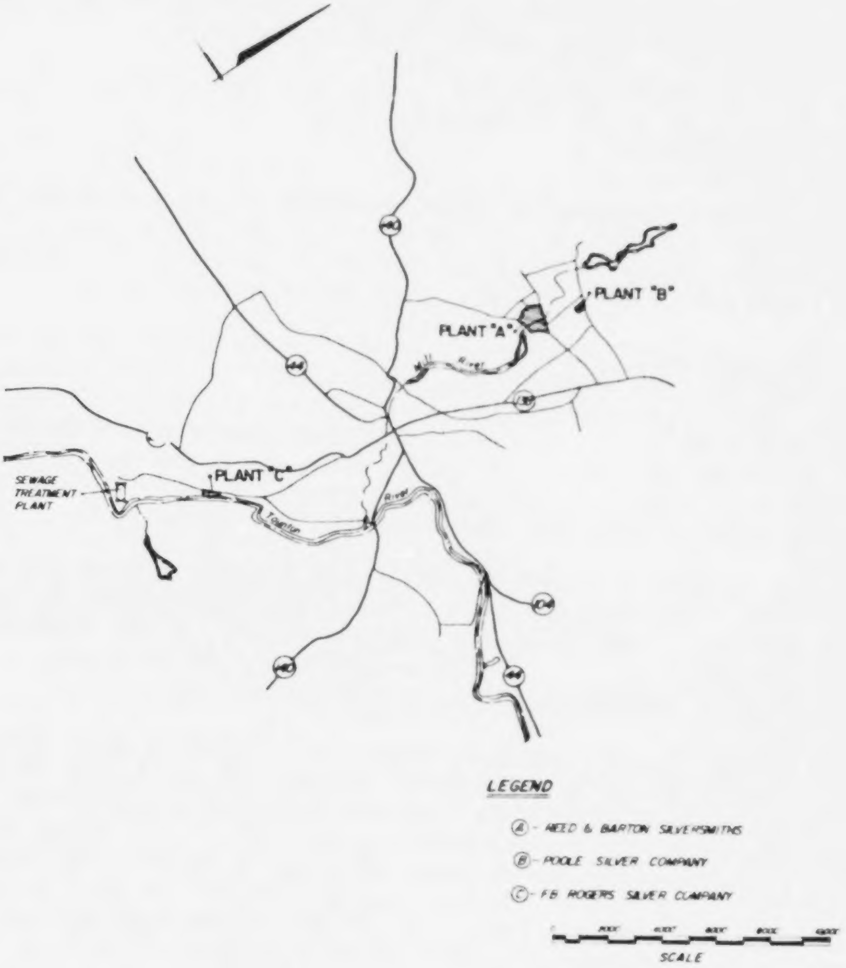
PLANT "A"
PLANT "B"
PLANT "C"
SEWAGE TREATMENT PLANT
Taunton River
River
LEGEND
A - REED & BARTON SILVERSMITHS
B - POOLE SILVER COMPANY
C - F.B. ROGERS SILVER COMPANY
SCALE

FIGURE 24. CITY OF TAUNTON

Option III--

One of the firms has installed concentrating equipment as a part of its waste treatment facility. The cation exchanger at F. B. Rogers removes the dissolved nickel from rinses. Five thousand (5,000) gallons per day is processed through the exchanger. Two thousand five hundred (2,500) gallons per month of concentrated waste is produced. This amounts to a concentrating effect that is 40:1. Rinse waters that previously would be considered to be impractical for transport to a common treatment facility can be considered to be converted into a manageable batch discharge. In a similar manner rinse waters following copper and silver cyanide plating at Sheffield Silver (a subsidiary of Reed & Barton) are concentrated by the use of evaporative recovery techniques.

The initial considerations for this option are directed toward the three companies involved. Expansion of the concept to allow for utilization by neighboring industry having similar waste is desirable.

Quality Objectives

The quality objectives of joint treatment of selected batch wastewater are based upon: the point(s) of discharge of the treated water (i.e. the river or the sanitary sewer), the salvage values of the resulting sludges, and the ultimate disposal site for sludges with little salvage value.

If the wastewater from batch treatment is to be discharged to the river, then the quality must meet the requirements as identified in Appendix F. The discharge should pass through the treatment facilities of flowing rinses at the treatment site as additional insurance of complete treatment. This concept is shown in the Primary Design discussed in Appendix A. The present laws in Massachusetts limit the expansion of these treatment facilities to firms generating waste within the state. Wastes from out of state are prohibited.

If the wastewater from batch treatment is to be discharged to the Taunton sanitary sewer, then the quality must meet the requirements as identified in Appendix E. Again, the discharge should pass through the treatment facilities for rinse waters. The local ordinance prohibits the discharge of waste from towns outside of Taunton (with one or two exceptions).

The design concepts employed result in salvable sludges that, at times, will be mixtures of silver with other metals. These sludges have a lower value to the refiner than those that are essentially only silver. Technologies could be developed which would permit separation of the silver and the copper--the most common combination of mixed metals. It is believed that this will become a viable concept if the quantity is adequate to justify the additional capital costs. Future considerations of this refinement will be dictated by economies. Those sludges that are devoid of silver, or have insignificant amounts of silver, will contain hydroxides and oxides of copper, zinc, nickel, iron, tin, lead and trivalent chromium. Considering the amounts of these metals for these three companies, the volume does not dictate attempts at salvage. There is one possible exception with chromium. If the other chemicals present with the concentrated chromate are not objectionable, this isolated waste could be sold to the tanning industry.

Those sludges resulting from waste treatment practices which do not have salvage values will be in the metal hydroxide or oxide state. With adequate protection at a disposal site to preclude mixing with solubilizing agents, these sludges are considered suitable for land disposal. The regulations relative to their disposal are provided in Appendix G.

Design Basis

The design basis for joint treatment of multicompany plating wastes initially considers only the combined wastes for the three firms under study. Expansion to include other companies' waste is a reasonable tenet.

Initial Basis--

The listing of batch wastes earlier in this appendix indicates the volumes and types of common waste for two or more plants. Where a unique waste exists at one plant (for examples--acid high in nickel at F. B. Rogers Silver Co.), waste treatment itself results in a sludge that is common to the other firm's waste. Consequently, the list can be expanded to include:

- acids high in nickel - 118,000 l/yr (31,000 gal/yr) resulting from ion exchange back wash and regeneration
- chromates - 910 kg/yr on a dry basis (2,000 lbs/yr)
- cyanides, low in metals - 32,000 l/yr (8,400 gal/yr).

From a treatability standpoint, the disposal techniques advocated for batch alkali cleaners require negligible expenses for disposal at the plant of origin. As all plants have sanitary sewer connections, and since this is the preferred disposal site, nothing is gained by shipping these relatively large volumes to a single common disposal site. Therefore, this type of batch waste is excluded from joint treatment considerations.

With the alkaline cleaners excluded, the total batch waste having as its sources the dumping of spent process solutions for the three companies is 130,000 gal/yr. This volume will be increased by floor spill containment and collection of accidental discharges. While these latter items are more difficult to quantify, it is reasonable to expect the volume will increase by 50 percent. Therefore, the initial design is based upon 200,000 gal/yr.

Additional wastewater results from each plant's treatment of flowing rinse waters for removal of cyanides and heavy metals. The sludges resulting from suspended solids settling become batch waste. F. B. Rogers has existing facilities for concentrating and dewatering the sludges. However, the volume of sludges originating at Poole Silver Company does not warrant extensive dewatering equipment. It is believed that it is practical to transport the somewhat concentrated sludge (approximately 5 percent solids) to Reed & Barton where further dewatering can be done to reduce ultimate disposal costs. Approximately 5,000 pounds a year are involved for nonsalvable sludges.

Of the total waste, over sixty percent originates at Reed & Barton Silversmiths. Considering costs to transport, it appears more practical to bring the waste to Reed & Barton than anywhere else. The other two firms have severe shortages of space for installing treatment facilities, while Reed & Barton does have room available. Based upon these two considerations, the design considers locating the joint treatment facility at Reed & Barton.

The initial design basis also considers that filtration of settler effluent (See Appendix A, Alternative Design A-1 and Appendix B, Alternative Design B-1) will not be required. If stream discharge is prohibited and filtration is required for these two firms, the amount of inert sludge having little salvage value will increase by 130,000 pounds a year, of which 30,000 pounds a year at five percent solids will be transported from Poole Silver Company to Reed & Barton.

Expansion Basis--

Two avenues for expansion of the joint treatment facility should be considered. In the first case, flow through treatment systems could be replaced with alternative equipment that would concentrate the waste into a quantity that would then be considered as a batch discharge. This could then be transported to the common treatment site and eliminate on-premise treatment of that particular waste. The other case considers including other firm's batch waste for disposal via the three-company joint treatment.

For expansion within the three-company project, the most likely candidate is Poole Silver Company. Evaporative recovery of cyanide rinse water is discussed in Appendix B, Alternative Design B-2. The concentrated batch wastes containing mixtures of copper and silver cyanides will amount to 540 gallons a year at concentrations comparable to that seen in dragout recovery tanks. This is considered a relatively small amount for transport to the Reed & Barton site. Another potential for expansion is concerned with nickel plating. F. B. Rogers by itself does not have enough isolated nickel waste to attract purchase by recovery firms. However, if Reed & Barton installs concentrating techniques (evaporative recovery or reverse osmosis), then the combined volume is close to that considered attractive to recovery firms.

Far greater potential for expansion exists beyond the three companies' participation. Within Taunton there are over fifteen companies producing metal related wastewaters. Expanding the area to be serviced to include the entire Southeastern Regional Planning and Economic Development District of Massachusetts, an area of over 900 square miles, then the number of firms increases to many hundreds. Obviously, not all of these firms have batch wastewaters which are amenable to the treatment systems originally conceived for this project. Consequently, a significant decision has been reached that forms a design basis for expansion of treatment facilities. This decision is that treatment facilities should be limited to those types of wastewaters which are comparable in quality. Expansion should include wastes that are like the eight involved in this project and which are listed earlier.

Those wastes that would present unique treatment considerations and which are dissimilar to these eight should not be considered in any expansion of this project. These incompatible wastes from the plating and metal finishing industry can produce an exhaustive list. To list a few examples: pickles used for ferrous alloys; ferrocyanides from descaling, heat treating, and plating bath purifications; highly chelated or ammoniated compounds common to the printed circuit industry; zinc and cadmium plating solutions, their dragout recovery and purification wastewater; and cyanide strips for nickel.

The decision to expand beyond Taunton requires acceptance for discharge of treated waters to the Mill River.

It is difficult to quantify the amount of batch waste that would be compatible with this present common treatment facility. These volumes will only be identified and known when pretreatment requirements prompt the individual firms to address their pollution problems. The concept used in the development of cost factors for the joint treatment facility under the initial design basis can be factored for increased utilization of basic equipment and, following that, expansion by multiples of that initially designed.

Treatment Proposed

In order to keep from being repetitive, a condensed discussion of the treatment proposed and a summary of cost factors are provided. For more details refer to Batch Wastewater Treatment as described in Appendix A, using Figure 8 as a schematic presentation.

Basically, the common treatment facility will have storage facilities for the eight types of batch wastes to be treated.

Those wastes that are acidic and high in salvable metal values will receive pretreatment to reduce the amount of metals in the acids. Then, combined with other less valuable acids, they will be neutralized for precipitation of heavy metals. The sludges resulting will be concentrated and dewatered prior to disposal on a suitable landfill site. The salvable metals will be either refined in-house (to be discussed later) or shipped out for recovery values.

Those wastes that contain cyanides receive treatment first to extract salvable values of silver (copper is a possibility); second, to destroy the cyanide by electrolysis (followed by chlorination); and third, to concentrate as a sludge for shipment to refiners with appropriate values recovered.

Major Components

Cost Factors--

The equipment will consist of storage facilities for receiving the batch waste; treatment equipment to salvage metal values; treatment equipment to produce insoluble heavy metal oxides and hydroxides; sludge concentrating and dewatering facilities; and disposal of residual water and accumulated inert sludges. Costs can be attributed to installation, space requirements, engineering support and operation expense.

Equipment--

Storage Tanks/Transfer Pumps		$ 22,700
Treatment Equipment		51,200
Sludge Concentration		27,700
Miscellaneous Support		6,000
	TOTAL	$107,600

Installation--	$ 24,000
Space Required-- @ 1,500 square feet	$ 32,260
Engineering Support--	$ 10,000

Operation-- (on annual basis)

Labor		$ 22,300
Energy		500
Chemicals		4,000
Maintenance Supplies		500
Sludge Disposal		9,000
Extramural		2,000
Transportation		3,000
	TOTAL	$ 41,300

Expanded Basis

The facilities described above will be suitable for the three firms combined for joint treatment. Some of the subsystems have been sized for optimizing labor used to support these systems. As a result, capacity exists for treating additional wastewater that can result from use of the various alternatives (except those dealing with filtration prior to sanitary sewer discharge). Additional excess capacity can be obtained by operating on a 24-hour day basis. As additional waste receives treatment, the first operation to reach maximum utilization is the high temperature electrolysis of cyanide; the second is sludge concentration.

Without adequate data to establish the quantities to be treated, it is impractical to establish cost factors for an expanded concept.

Salvage or recovery values in the joint facility have been limited primarily to silver and, to a minor extent, copper. The volumes of other metals are not adequate to be attractive to refiners. Should the amount of any specific heavy metal (for example, nickel) increase to the point it is a salable commodity, expansion and segregation should be considered. Under similar circumstances, it may become attractive to provide more sophisticated processing to separate silver and copper from cyanides high in these combined metals. Cost assessments at this point would be strictly speculative.

APPENDIX E

EXCERPTS FROM THE CITY OF TAUNTON SEWER ORDINANCE

REGULATION OF SEWER USE: ORDINANCE

AN ORDINANCE REGULATING THE USE OF PUBLIC SEWERS AND DRAINS, THE INSTALLATION AND CONNECTION OF BUILDING SEWERS, AND THE DISCHARGE OF WATERS AND WASTES INTO THE PUBLIC SEWER SYSTEMS, AND PROVIDING PENALTIES FOR VIOLATIONS THEREOF, IN THE CITY OF TAUNTON, COUNTY OF BRISTOL, STATE OF MASSACHUSETTS.

BE it ordained and enacted by the Municipal Council of the City of Taunton, State of Massachusetts as follows:

ARTICLE I - Purpose

The purpose of this Ordinance is to provide for the use of the publicly owned Sewerage Facilities by Industries served by the City of Taunton without damage to the physical facilities, without impairment of their normal function of collecting, treating and discharging domestic wastewaters from the area served by the City, and without the discharge by the publicly owned treatment works of pollutants which would be in violation of its permitted discharge under the applicable rules and regulations of State and Federal regulatory agencies.

ARTICLE II - Definitions

ARTICLE III - Building Sewers and Connections

ARTICLE IV - Prohibitions and Limitations on Wastewater Discharges

Section 1. Prohibitions on Wastewater Discharges

No person shall discharge or cause or allow to be discharged into the Taunton Sewerage Facilities or any connected Treatment Facilities any waste which contains any of the following:

(a) Oils and Grease

Any water or waste containing fats, wax, grease or oils whether emulsified or not, in excess of one hundred (100) mg/l or containing substances which may solidify or become viscous at temperatures between thirty-two (32) and one hundred fifty (150°F) (0 and 65°C); at the point of discharge into the system.

(b) Explosive Mixtures

Liquids, solids, or gases which by reason of their nature or quantity are, or may be, sufficient to cause fire or explosion or be injurious in any other way to the sewerage facilities or to the operation of the system. Prohibited materials include but are not limited to: gasoline, kerosene, naphtha, benzene, toluene, xylene, ethers, alcohols, ketones, aldehydes, peroxides, chlorates, perchlorates, bromates, carbides, hydrides, and sulfides.

(c) Noxious Materials

Any waters or wastes containing phenols or other taste or odor producing substance, in such concentrations exceeding limits which may be established by the Superintendent as necessary after treatment of the composite sewage to meet the requirements of the State, Federal, or other public agencies or jurisdiction for such discharge to the receiving waters.

(d) Improperly Shredded Garbage

Any garbage that has not been properly shredded, with no particle greater than one-half (1/2) inch in any dimension. The installation and operation of any garbage grinder equipped with a motor of three-fourths (3/4) horsepower (0.76 hp metric) or greater shall be subject to the review and approval of the Superintendent.

(e) Radioactive Wastes

Any radioactive wastes or isotopes of such half-life or concentration that they are in compliance with regulations issued by the appropriate authority having control over their use and which will or may cause damage or hazards to the sewage facilities or personnel operating the system.

(f) Solid of Viscous Wastes

Solid or viscous wastes in quantities or of such size capable of causing obstruction to the flow in sewers, or other interference with the proper operation of the sewage works. Prohibited materials include, but are not limited to: grease, underground garbage, animal intestines or tissues, paunch manure, bones, hair, hides or fleshings, entrails, whole blood, feathers, ashes, cinders, sand, spent lime, stone or marble dust, metal, glass, straw, shavings, grass clippings, rags, spent grains, spent hops, waste paper, wood, plastic, tar, asphalt residues, residues from refining or processing of fuel or lubricating oil, and similar substances.

(g) Excessive Discharge Rate

Wastewaters at a flow rate which is excessive relative to the capacity of the treatment works and which would cause a treatment process and subsequent loss of treatment efficiency; or wastewaters containing such concentrations or quantities of pollutants that their introduction into the treatment works over a relatively short time period (referred to as a slug discharge) would cause a treatment process upset and subsequent loss of treatment efficiency.

(h) Toxic Substances

Any water or wastes containing toxic or poisonous solids, liquids, or gases in sufficient quantity, either singly or by interaction with other wastes, to injure or interfere with any sewage treatment process, constitute a hazard to humans or animals, create a public nuisance, or create any hazard in the receiving waters of the sewage treatment plant.

(i) Unpolluted Waters

No person shall discharge or cause to be discharged stormwater, surface water, groundwater, roof runoff, subsurface drainage, uncontaminated cooling water, or unpolluted industrial process water to any sanitary sewer. Stormwater and all other unpolluted drainage shall be discharged to such sewers as are specifically designated as combined sewers or storm sewers. Industrial cooling water or unpolluted process waters may be discharged, on approval of the Superintendent, to a storm sewer or combined sewer.

(j) Discolored Material

Any wastes with objectionable color (such as, but not limited to, dye wastes and vegetable tanning solutions) not removable by the treatment process.

(k) Corrosive Wastes

1. Any wastes which will cause corrosion or deterioration of the sewage facilities. All wastes discharged to the public sewer system must have a pH in the range of 5.5 to 9.5. Prohibited materials include, but are not limited to, acids, sulfides, concentrated chloride and fluoride compounds and substances which will react with water to form corrosive products.

2. Any organic solvents which may interfere with the operation of the wastewater collection system or the sewage treatment plant; or which may result in a violation of the City's NPDES permit.

(l) Miscellaneous Materials

1. Unusual concentrations of inert suspended solids (such as, but not limited to, Fuller's earth, lime slurries, and lime residues or of dissolved solids (such as, but not limited to, sodium chloride and sodium sulfate.)

2. Any liquid or vapor having a temperature higher than one hundred fifty degrees (150°F or 65°C).

3. Any waters or wastes exerting an excessive chlorine requirement.

4. Unusual volume of flow or concentration of wastes constituting "slugs" as defined herein.

(m) Untreatable Wastes

"Waters or wastes containing substances which are not amenable to treatment or reduction by the sewage treatment process employed, or are amenable to treatment only to such degree that the sewage treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters."

Section 2. Specific Limitation of the Discharge of Pollutants

The following is a partial list of the maxium concentrations of pollutants allowable in wastewater discharges to the Public Sewer (dilution of any wastewater discharge for the purpose of satisfying these requirements shall be considered a violation of the ordinance):

Substance	Maximum Concentration Allowable in Milligrams per Liter
Arsenic	0.1
Cadmium	0.2
Chromium (Total)	1.0
Copper	2.0
Cyanides	1.0
Lead	1.0
Mercury	0.01
Nickel	1.0
Silver	1.0
Zinc	3.0

Any industry discharging wastes which exceed the following concentrations must obtain additional written approval from the Sewer Commissioners:

Total Solids	5,000
Suspended Solids	1,000
BOD	1,000
COD	2,000

ARTICLE V - Control of Prohibited Wastes

ARTICLE VI - Industrial Wastewater Sampling and Analysis

ARTICLE VII - Industrial Discharge Permit System

ARTICLE VIII - Protection from Damage

ARTICLE IX - Penalties

ARTICLE X - Industrial Self-Monitoring Requirements

ARTICLE XI - Validity

ARTICLE XII - Ordinance in Force

APPENDIX F

REGULATIONS FOR RIVER DISCHARGE ANTIDEGRADATION REQUIREMENTS OF THE MASSACHUSETTS WATER QUALITY STANDARDS*

(Water Resources Commission Rules and Regulations for the Establishment of Minimum Water Quality Standards and for the Protection of the Quality and Value of Water Resources; Adopted April 11, 1974; Effective May 2, 1974)*

REGULATION III - General Provisions

1. It is recognized that certain waters of the Commonwealth possess an existing quality which is better than the standards assigned thereto.
   A. Except as otherwise provided herein, no new discharge of wastewater will be permitted into any stream, river or tributary upstream of the most upstream discharge of wastewater from a municipal waste treatment facility or municipal sewer discharging wastes requiring appropriate treatment as determined by the Division. Any person having an existing wastewater discharge shall be required to cease said discharge and connect to a municipal sewer unless it is shown by said person that such connection is not available or feasible. Existing discharges not connected to a municipal sewer will be provided with the highest and best practical means of waste treatment to maintain high water quality. New discharges from a municipal waste treatment facility into such waters will be permitted provided that such discharge is in accordance with a plan developed under the provisions of Section 27(10) of Chapter 21 of the General Laws (Massachusetts Clean Waters Act) which has been the subject of a Public Hearing and approved by the Division. The discharge of industrial liquid coolant wastes in conjunction with the public and private supply of heat or electrical power may be allowed provided that a permit has been issued by the Division and that such discharge is in conformance with the terms and conditions of the permit and in conformance with the water quality standards of the receiving waters.
   B. Except as otherwise provided herein no new discharge of wastewater will be permitted in Class SA or SB waters. Any person having an existing discharge of wastewater into Class SA or SB waters will be required to cease said discharge and to connect to a municipal sewer unless it is shown by said person that such connection is not available or feasible. Existing discharges not connected to a municipal sewer will be provided with the highest and best practical means of waste treatment to maintain high water quality. New discharges from a waste treatment facility into such waters will be permitted provided that such discharge is in accordance with a plan developed under the provisions of Section 27 (10) of Chapter 21 of the General Laws (Massachusetts Clean Waters Act) which has been the subject of a Public Hearing and approved by the Division. The discharge of industrial liquid coolant wastes in conjunction with the public and private supply of heat or electrical power may be allowed provided that such discharge is in conformance with the Water Quality Standards of the receiving waters.

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* These provisions were in effect at the time of the project. They have since been expanded to include protection of existing uses and specific resources.

DIVISION OF WATER POLLUTION CONTROL REQUIREMENTS ON METAL FINISHING EFFLUENTS*

Pollutant Concentrations for Operational Treatment Facilities[†, ‡]

	Daily Average[§] (mg/1)	Daily Maximum[§] (mg/1)
TSS	20	30
Cyanide (Dest. by Cl_2)	0.05	0.01
Cyanide (Total)	0.5	1.0
Fluoride	18	36
Aluminum	0.5	1.0
Barium	2.0	4.0
Cadmium	0.2	0.2
Chromium (+6)	0.05	0.1
Chromium (Total)	0.5	1.0
Copper	0.5	1.0
Iron	1.0	2.0
Lead	0.1	0.2
Manganese	2.0	4.0
Nickel	2.0	2.0
Silver	0.05	0.1
Zinc	0.5	1.0
Tin	1.0	2.0
pH	6.0-9.5 range	

*Letter to Region IEPA: Metal Finishing Permits Revised Format, Table I; The Commonwealth of Massachusetts, Water Resources Commission, Division of Water Pollution Control, July 3, 1974.

[†] Metal concentrations are based on analysis of filtered sample using a 0.4 micron membrane filter. The maximum permissible concentration for a particular metal in the total suspended solids shall be 1 mg/l.

[‡] These limitations shall apply to small metal finishers (less than 33 m^2/hr) for the initial five-year permit and to large metal finishers (greater than 33 m^2/hr) until June 30, 1977.

[§] Daily Average value referes to an eight grab composite collected over a normal operating day. Daily Maximum value refers to an individual grab sample. Both values are explicitly defined in the permit.

APPENDIX G

SOLID AND HAZARDOUS WASTE REGULATIONS

"Special Wastes - Materials such as sewage solids, radio-active wastes, pathologic wastes, explosive materials, chemicals, certain liquid wastes, or other materials of hazardous nature or materials requiring handling or procedures for disposal."

Regulation 16. Special Wastes*

16.1 The operator may make special provisions for the limited disposal of certain special wastes; provided that such disposal may be conducted in a separate area specially designated for this purpose and with the permission of the assigning agency. A copy of the permit for the disposal of such special wastes shall be filed with the Department of Public Health and the Division of Water Pollution Control.

16.2 The handling and disposal of certain chemical and other hazardous wastes shall be in accordance with Section 57 and 58 of Chapter 21 of the General Laws. (Generally these wastes must be licensed by the Division of Water Pollution Control.)

Hazardous Wastes

The following classes of materials are identified as hazardous wastes within the scope of these regulations. Materials may be added to or removed from each category or additional categories established by action of the Hazardous Wastes Board.**

Waste Oils - Materials which are classified as waste oils include those oils having flash points at or about 100° F which are no longer usable for the services for which they were manufactured due to the presence of impurities or loss of certain compounds. These include but are not limited to crude oil, fuel oils, lubricating oils, kerosene, diesel fuels, cutting oil emulsions, hydraulic oils and other nonchlorinated industrial oils that are discarded as waste or are recovered from oil separators, oil spills, tank bottoms or other sources.

Solvent and Chlorinated Oils - Materials classified under this heading include insoluble or partially soluble organic chemicals and petroleum derivatives which require special disposal precautions because of flammability (i.e. flash points below 100°F), toxicity or composition (i.e.contain elements such as chlorine or sulfur in concentrations which prohibit conventional incineration). These include but are not limited to chlorinated solvents and oils, gasoline, aromatics, organic pesticides, polychlorinated biphenyls, and low-boiling insoluble ketones, alcohols and ethers.

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* Massachusetts Regulations for the Disposal of Solid Wastes by Sanitary Landfill (Massachusetts Division of Environmental Health; Effective April 21, 1977)

** Massachusetts Hazardous Waste Regulations (Massachusetts Division of Water Pollution Control Hazardous Waste Regulations; Effective January 11, 1973).

Toxic Metals Etchants, Pickling and Plating Wastes - Materials which are classified under this heading are aqueous solutions and sludges containing cyanides or toxic metals which include but are not limited to mercury, beryllium, cadmium, chromium, nickel, copper, lead, zinc, arsenic, thallium and antimony.

Explosives, Reactive Metals and Compounds - Materials which are classified under this heading are explosives and materials which are highly reactive either by themselves or on contact with water to form ions or compounds normally present in sea water. These include but are not limited to lithium, sodium, magnesium, aluminum, potassium and titanium metals and their highly reactive inorganic compounds.

Hazardous, Chemical, Biological and Radioactive Wastes - Materials included under this heading include military (nerve) gases, other biological and chemical warfare agents, radioactive wastes and compounds assigned a moderate or serious hazard category (No. 2 or greater) in the National Fire Protection Association identification system and not otherwise classified above, or equipment containing or contaminated by such hazardous materials.

Handling of Hazardous Wastes

3.1 Except as provided in Regulation 1.0, no person shall engage in the collection, conveyance or disposal of hazardous wastes classified within the scope of these regulations from any site to a disposal site off the premises without having obtained a license from the Division of Water Pollution Control, issued in accordance with these regulations, for the appropriate class(es) of hazardous wastes as determined by the Board.

3.2 Except as provided in Regulation 1.0, no person shall operate a waste disposal facility, landfill site, or storage facility for hazardous wastes classified within the scope of these regulations without having obtained a license from the Division of Water Pollution Control, issued in accordance with these regulations, for the appropriate class(es) of hazardous wastes as determined by the Board.

3.3 No person shall dispose of hazardous wastes at a land site in the Commonwealth unless the site has been approved by the Division of Water Pollution Control for disposal of that class of wastes. Any land disposal site will also be subject to current Regulations for the Disposal of Solid Wastes by Sanitary Landfill, as adopted by the Division of Environmental Health, Massachusetts Department of Public Health.

3.4 No person shall transport hazardous wastes through waters of the Commonwealth for the purpose of off-shore disposal nor dispose of hazardous wastes in waters of the Commonwealth unless off-shore disposal of that class of waste has been approved by the Division of Water Pollution Control and disposal is accomplished in a dumping ground designated by the Division. In no case shall the following be dumped in any of the waters of the Commonwealth:

1. Mercury and mercury compounds.
2. Beryllium and beryllium compounds.
3. Cadmium and cadmium compounds.
4. Arsenic, lead and thallium, and compounds thereof.
5. Organohalogen compounds and compounds which may form such matters in the marine environment, including but not limited to Aldrin, Lindane, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene, Polyhalogenated Biphenyls, (PCB), and Toxaphene.
6. Waste oils taken on board for the purpose of dumping.
7. Radioactive wastes.
8. Military (nerve) gases and other biological and chemical warfare agents.
9. Materials in the highest health hazard category (#4) in the National Fire Protection Association identification system.

3.5 Wastes shall be strictly segregated by classes by the originators and the persons involved in collection, conveyance and disposal of the wastes. All hazardous wastes shall be stored and maintained in such a manner that the contents of a ruptured container or other source of spillage, whether accidental or otherwise, will not cause or contribute to a condition in contravention of the Water Quality Standards.